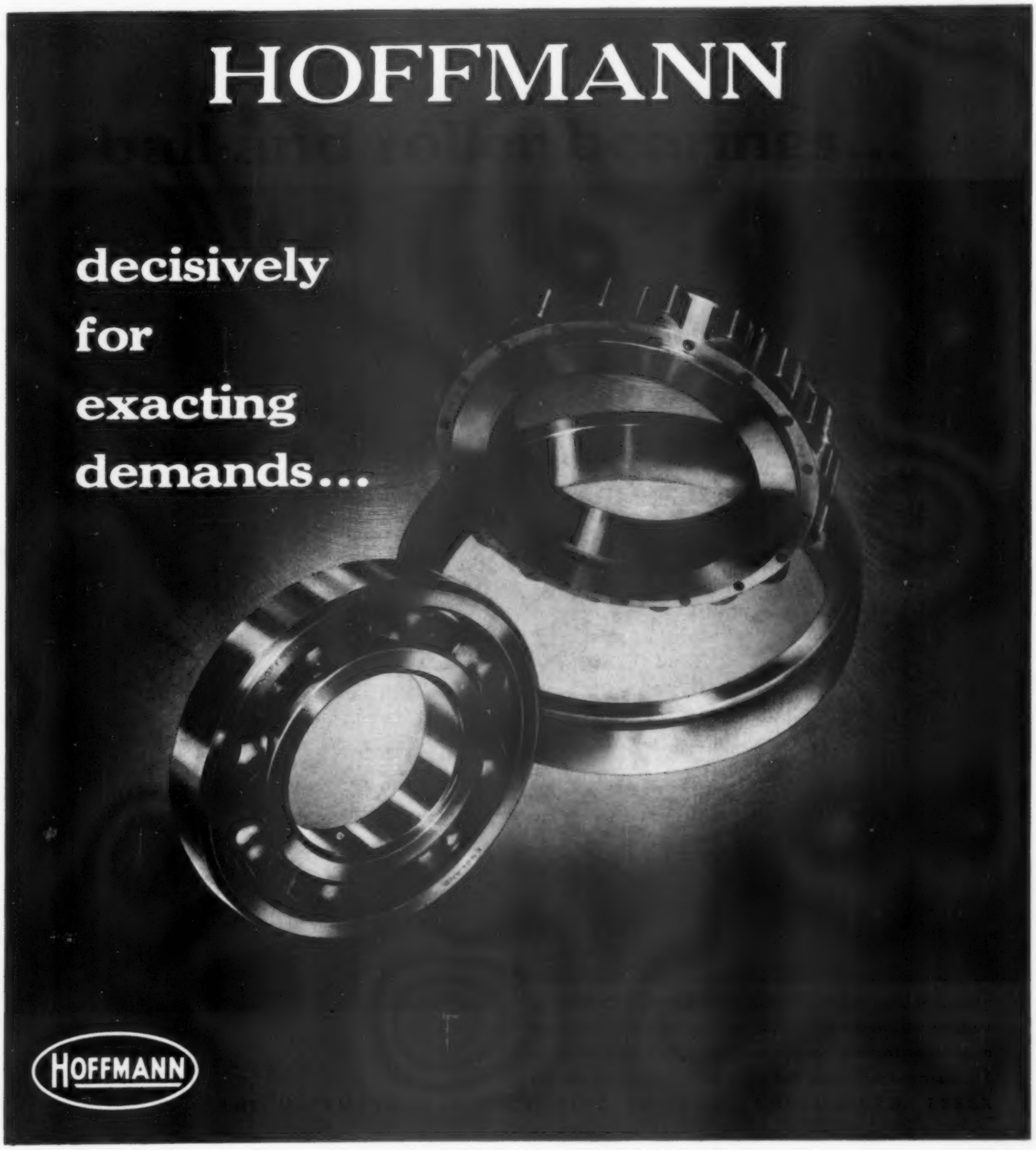
AUTOMOBILE ENGINEER

SEPTEMBER 1961

Three Shillings & Sixpence



The assembly line of Ford Motor Company Ltd. at Dagenham, where "BROOMWADE" Compressed Air equipment is used.

Photograph by courtesy of Ford Motor Company Ltd.

Men who build cars use "BROOMWADE" Air Compressors & Pneumatic Tools

YOUR BEST INVESTMENT

British Cars have won a world-wide reputation for design and quality. The demand is increasing. As a result, new factories with longer production lines are being built and equipped with the most modern equipment.

For many years, "BROOMWADE" pneumatic equipment has served this industry well and it is significant that the demand for "BROOMWADE" products is also increasing. There are outstanding reasons for this—ECONOMY, EFFICIENCY and RELIABILITY coupled with intensive research and development to keep "BROOMWADE" Air Compressors and Pneumatic Tools up-to-date with modern trends and requirements.

In addition, "BROOMWADE" Technical Representatives and Service Engineers are works trained to provide customers with the best advice and service.

"BROOMWADE" manufacture a wide range of Air Compressors and Pneumatic Tools covering the requirements of the engineering industry.

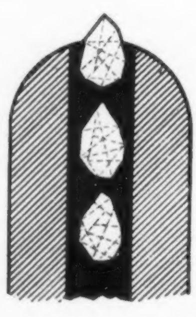
BROOM & WADE LTD., P.O. BOX NO. 7, HIGH WYCOMBE, BUCKS.
Telephone: High Wycombe 1630 (10 lines) Telex: 83-127

737/1 SAS

KNOW YOUR DIAMOND

Physical properties

Properly applied, diamond is the supreme cutting material because it is the hardest substance known. It is about five times as hard as tungsten carbide or corundum, and this property is derived from the enormously high temperatures and pressures under which it is formed. The use of diamond for cutting purposes, however, poses special problems, since its strength does not match its hardness. Tensile strength, clearly, is unimportant in this context, but the low compressive strength demands that diamond tools be carefully handled, while adequate support of the stone is necessary to counter the relative weakness in shear.



Data sheets available

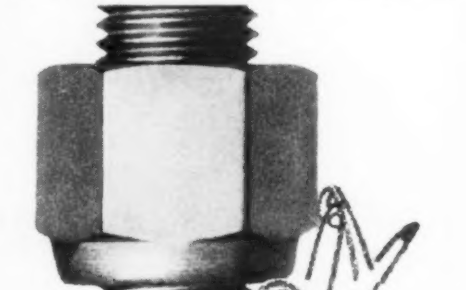
L.M. VAN MOPPES & SONS (DIAMOND TOOLS) LTD
BASINGSTOKE · HAMPSHIRE · ENGLAND

TELEPHONE: BASINGSTOKE 1240 TELEGRAMS: DIATIPT, BASINGSTOKE


Hyline TAKES THE WEIGHT OUT OF STEERING.....
In the field of Power steering, Hyline Assemblies have already proved their efficiency over a number of years.
The hose has been developed to give maximum burst rating and high impulse life with adequate safety margin, controlled volumatic expansion and noise restriction.
End fittings are produced to customers' specifications.
Descriptive literature showing sizes and working pressures is available on request to our Publicity Dept., Birmingham, whilst our Technical Sales Staff at Redditch will gladly advise on specific application problems.
Hyline
POWER STEERING ASSEMBLIES
SUPER OIL SEALS AND GASKETS LIMITED
FACTORY CENTRE BIRMINGHAM 30
TELEPHONE: KINGS NORTON 2041
HOSE DIVISION, STUDLEY RD., REDDITCH, WORCS.
TELEPHONE: REDDITCH 3661

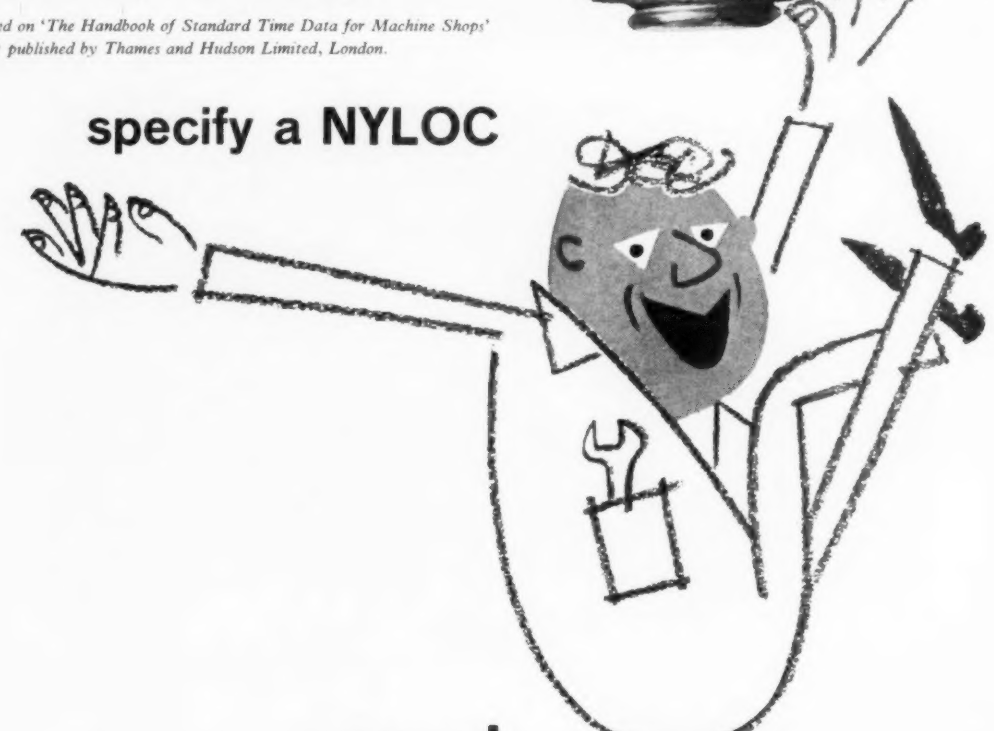
when everything depends on a nut

A lot can depend on a single nut—safety, efficiency, your reputation as a manufacturer. If that's the sort of exacting role the nut has to play, there are six good reasons why you should choose a Nyloc: * Nylocs are self-locking anywhere on the bolt thread. * Nylocs stand up to shock, vibration, oil, corrosives and extremes of temperature. * Nylocs can be used again and again. * Nylocs don't damage the bolt thread. * Nylocs have no extra bits and pieces to fit or get lost. * Nylocs save time and money (it takes 40 minutes to assemble 100 $\frac{1}{4}$″ Nylocs as against 60 minutes to assemble 100 $\frac{1}{4}$″ full nuts and jam nuts*). If you want still more reasons, send for the Nyloc brochure—it's free and includes complete tables of all Nyloc types, sizes, threads, materials and finishes.



** These times are based on 'The Handbook of Standard Time Data for Machine Shops' by Haddon & Genger published by Thames and Hudson Limited, London.*

specify a NYLOC



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TREFOREST, PONTYPRIDD, GLAMORGAN

Branches: LONDON · BIRMINGHAM · MANCHESTER · STOCKHOLM COPENHAGEN · BALLARAT · SYDNEY · JOHANNESBURG · NAARDEN MILAN · NEW YORK · BRUSSELS AND MANNHEIM

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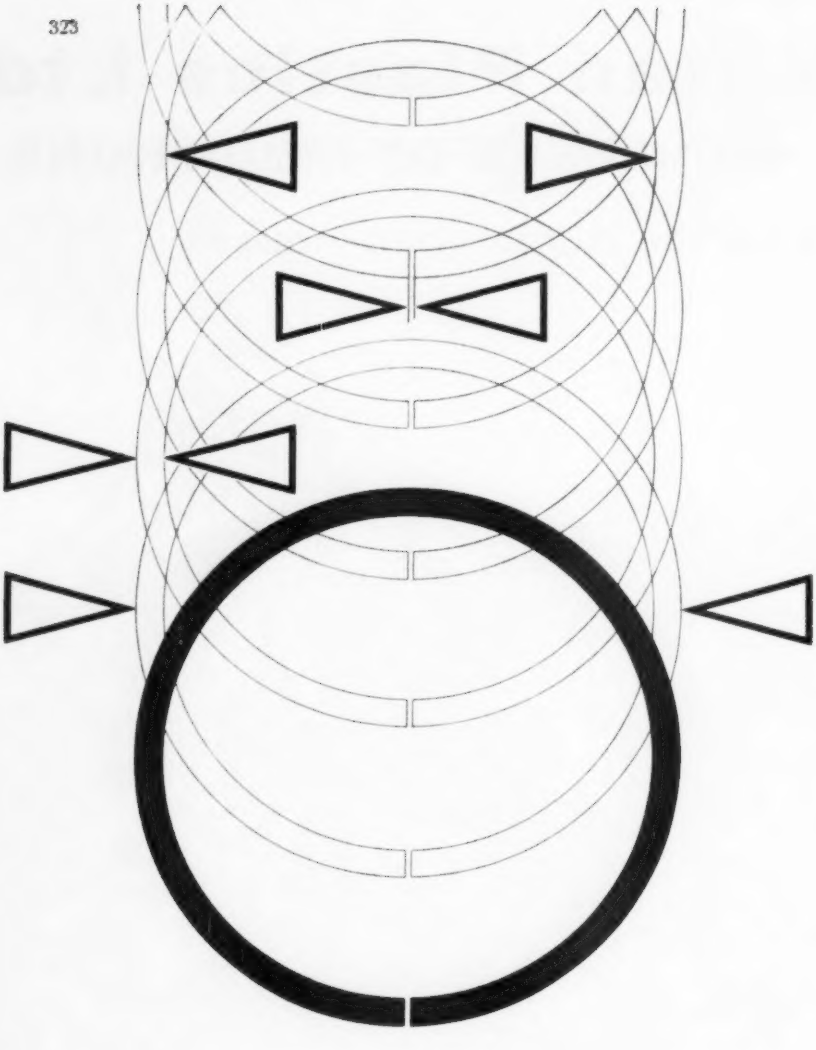
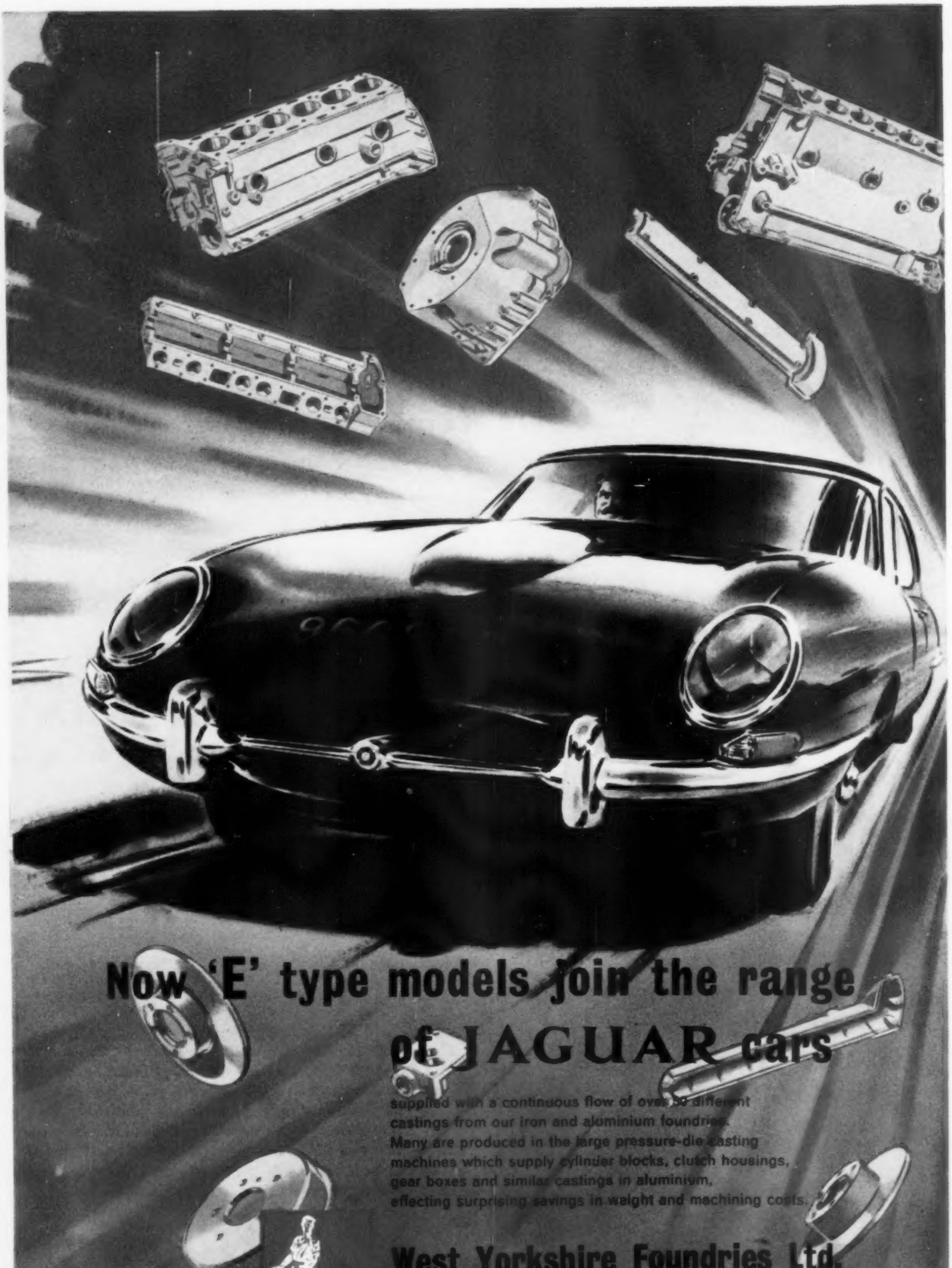
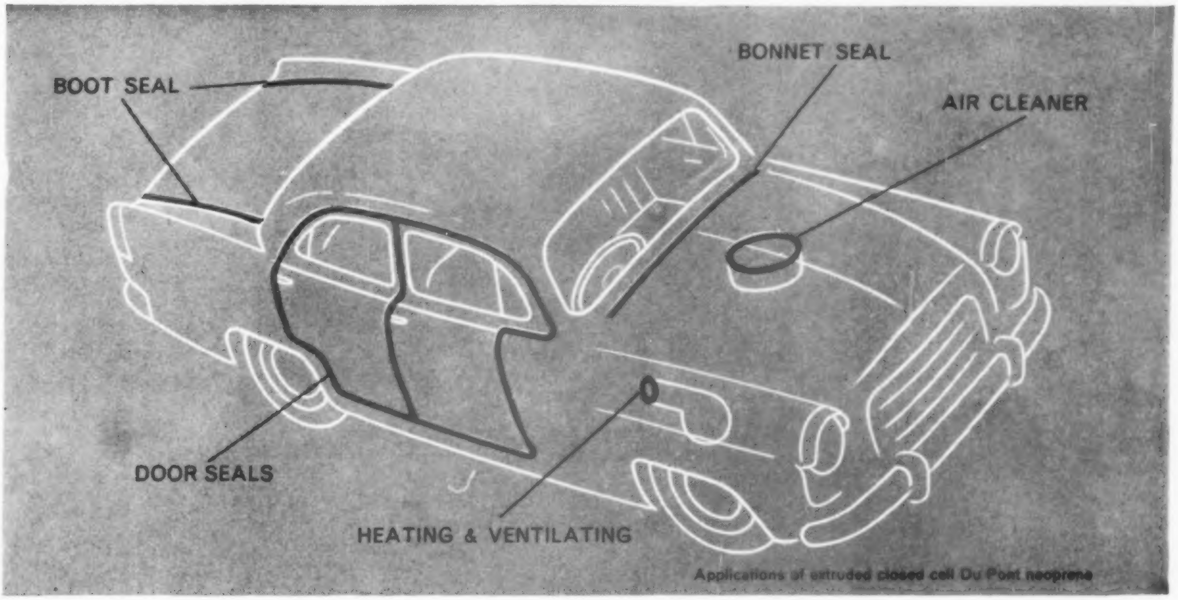
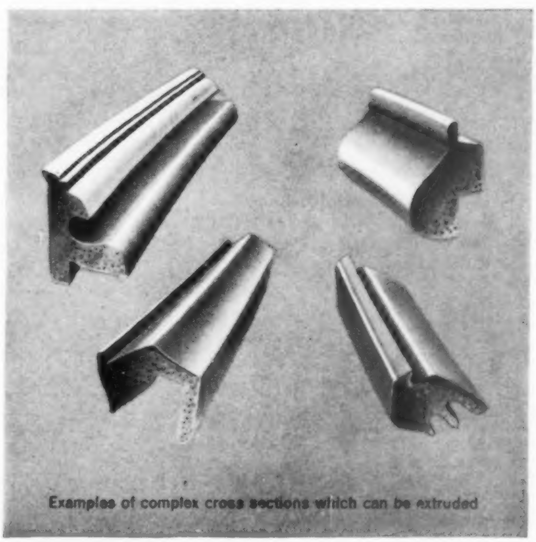



Now 'E' type models join the range
of JAGUAR cars
supplied with a continuous flow of over different
castings from our iron and aluminium foundries.
Many are produced in the large pressure-die casting
machines which supply cylinder blocks, clutch housings,
gear boxes and similar castings in aluminium,
effecting surprising savings in weight and machining costs.
West Yorkshire Foundries Ltd.
SAYNER LANE, LEEDS, 10. Telephone: LEEDS 29466.
London Office: Hanover House, Hanover Square, W.1. Phone: MAYfair 8561.

A new and improved body seal: EXTRUDED CLOSED CELL **DU PONT NEOPRENE**



Applications of extruded closed cell Du Pont neoprene


Examples of complex cross sections which can be extruded

NEW APPROACHES TO BODY SEALING AND GASKETING are possible with extruded closed cell Du Pont neoprene. It can be extruded into low-pressure body seals of controlled softness that offer high resistance to ozone and weathering, and have low water absorption. The "self-skin" of these extrusions and the closed cell structure beneath remove the need for a protective coating. Tighter radii can be turned without wrinkling to provide an effective seal. For more information post coupon for your copy of 'Extruded Closed Cell Neoprene Sponge'.

Du Pont Company (United Kingdom) **Ltd.,**
76 Jermyn Street, London, S.W.1

DU PONT REG. U.S. PAT. OFF. ESTABLISHED 1802 **NEOPRENE**

BETTER THINGS FOR BETTER LIVING . . . . *THROUGH CHEMISTRY*

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London, S.W.1, England
Please send me the Du Pont booklet
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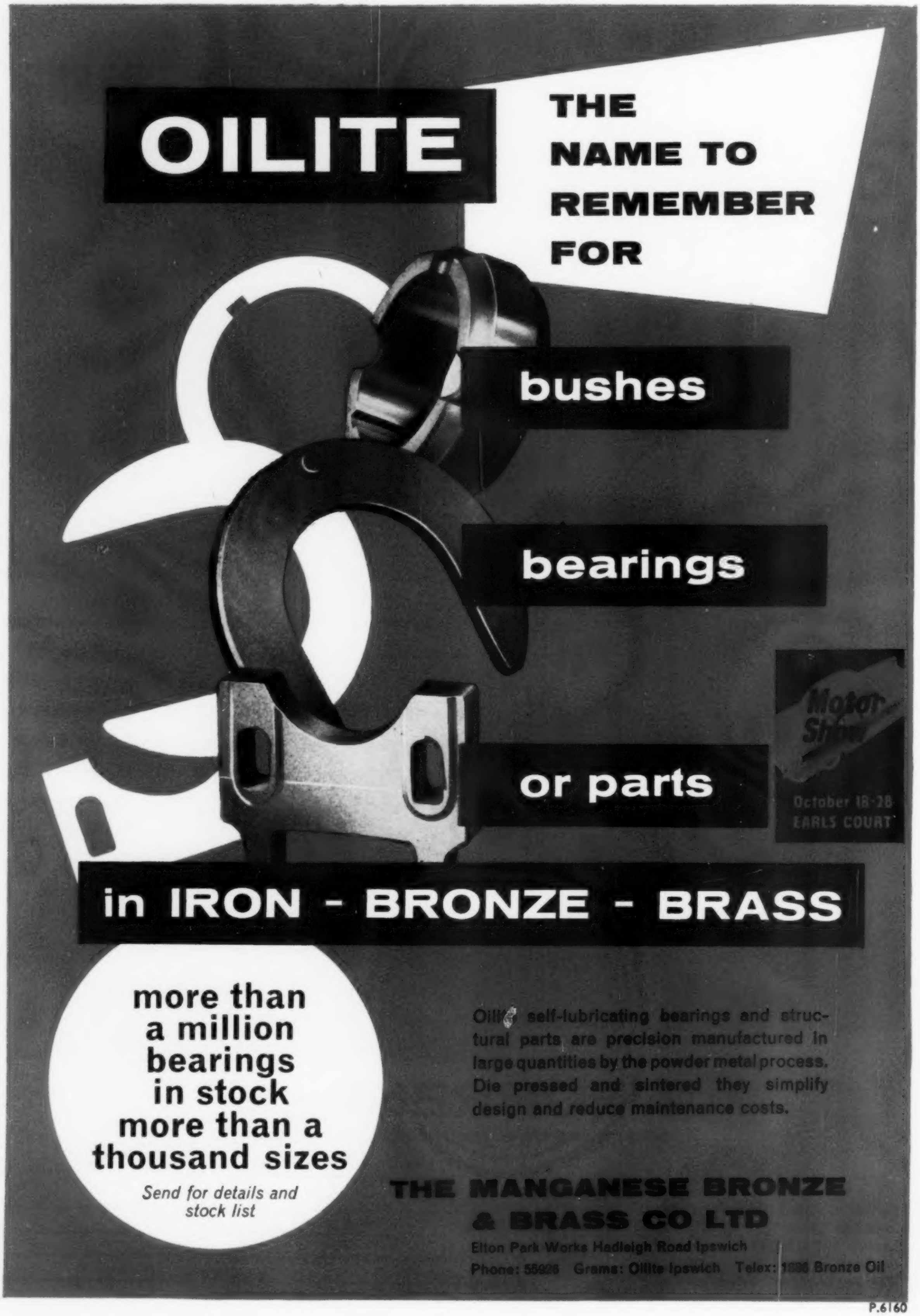
Auto Engineer 9/61

NAME________________________
POSITION____________ COMPANY____________
ADDRESS________________________
CITY____________ COUNTRY____________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THE NAME TO REMEMBER FOR
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October 18-28
EARLS COURT
in IRON - BRONZE - BRASS
more than a million bearings in stock more than a thousand sizes
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Oilite self-lubricating bearings and structural parts are precision manufactured in large quantities by the powder metal process. Die pressed and sintered they simplify design and reduce maintenance costs.
THE MANGANESE BRONZE & BRASS CO LTD
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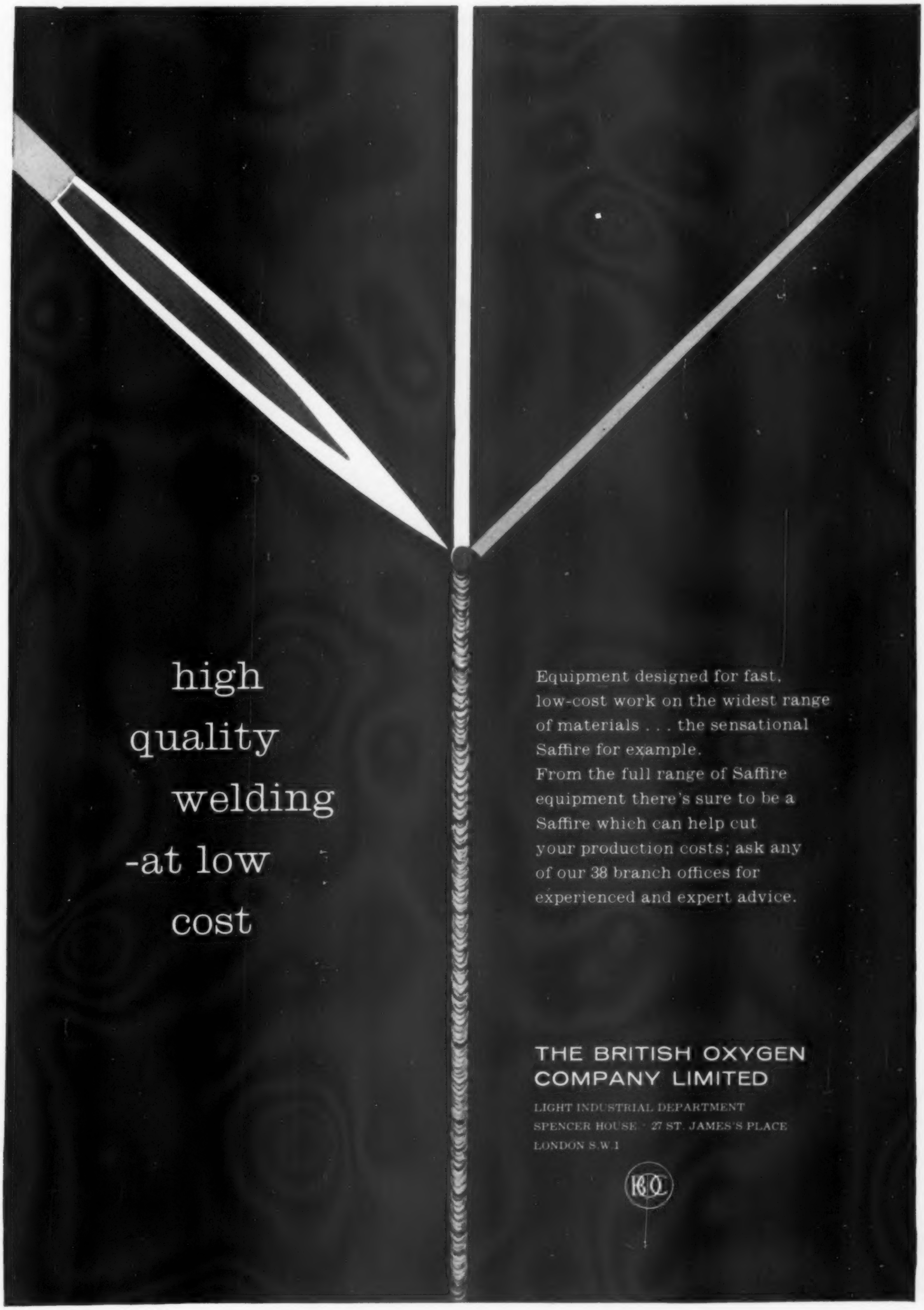
P.6160


high
quality
welding
-at low
cost
Equipment designed for fast, low-cost work on the widest range of materials . . . the sensational Saffire for example.
From the full range of Saffire equipment there's sure to be a Saffire which can help cut your production costs; ask any of our 38 branch offices for experienced and expert advice.
THE BRITISH OXYGEN COMPANY LIMITED
LIGHT INDUSTRIAL DEPARTMENT
SPENCER HOUSE · 27 ST. JAMES'S PLACE
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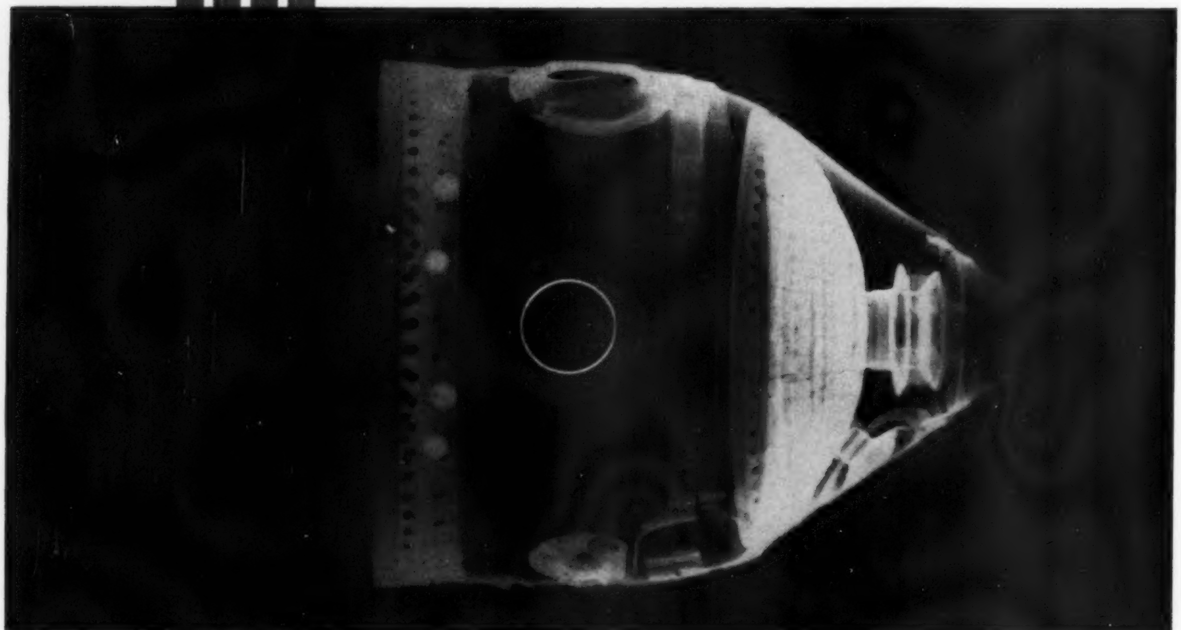
For radiographing assemblies, castings and welded seams



ILFORD Industrial "B" X-ray film is a general purpose film suitable for the non-destructive examination of encased assemblies, as well as for light alloy castings, steel castings and seams in pressure vessels.
Its characteristics are high speed with fine grain, providing excellent definition with high contrast. ILFORD Industrial "B" film gives the best results when it is developed in ILFORD Phenisol high-energy concentrated liquid developer. It is suited to radiography with X-rays or gamma rays.

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INDUSTRIAL "B" X-RAY FILM

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They meet the continuous high speed operation of a pump, maintain the precise setting of a lathe headstock, withstand the stop/start punishment of an electric drill —angular contact bearings are designed for every requirement of continuous thrust loading.

Ransome and Marles produce these bearings in a comprehensive range of sizes and tolerances. The designs can include built-in preload which eliminates shims or adjustments on assembly. The bearing specification can be arranged to suit the precise requirements of any particular application.

Ransome and Marles will be pleased to advise you on the application of angular contact bearings. Call them in when designing, developing or modifying machines of any type or size; their guidance is expert, impartial and confidential. Publication 37 is a comprehensive introduction to Ransome and Marles bearings.

RANSOME & MARLES BEARING COMPANY LIMITED

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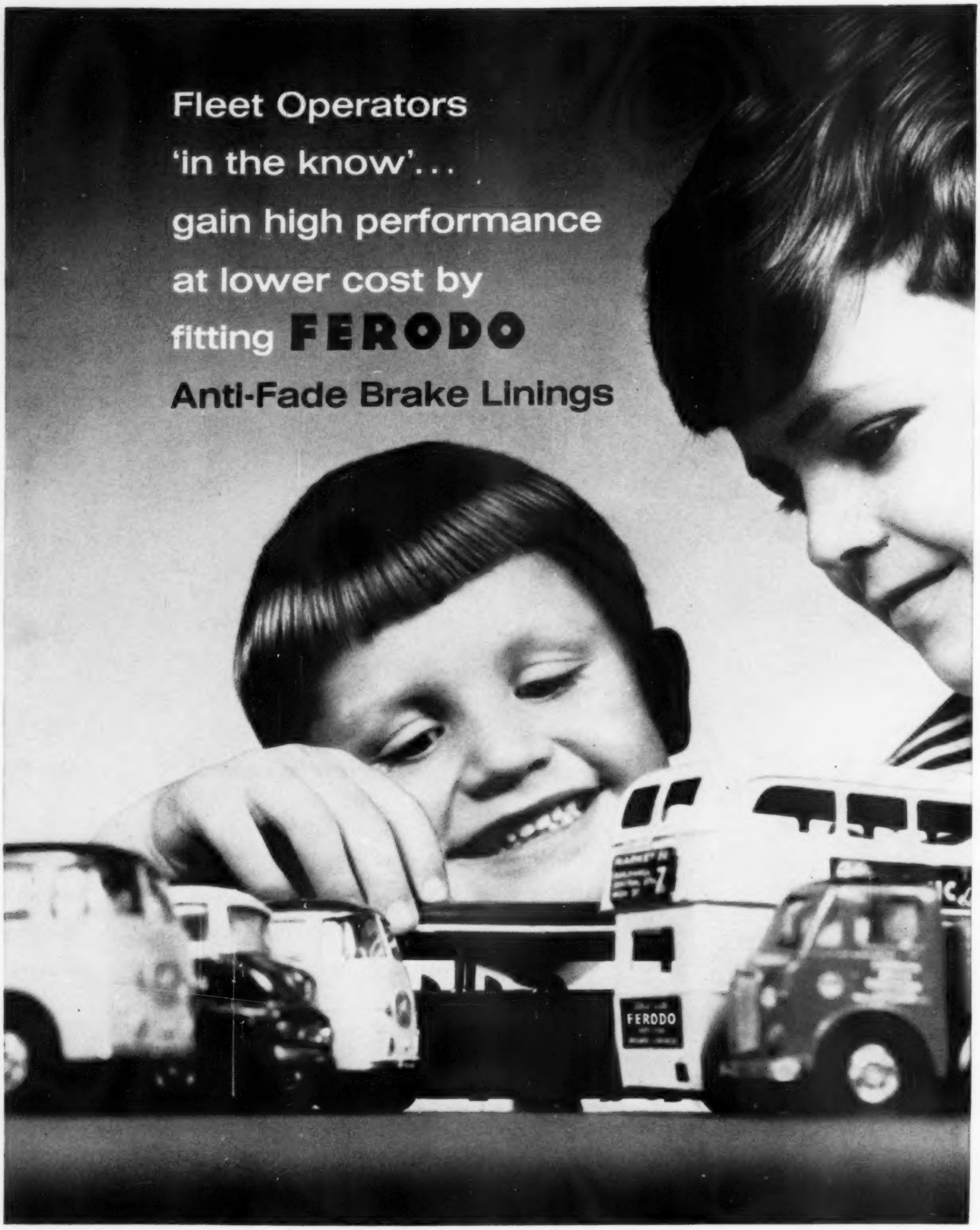


Fit **FERODO**

Anti-Fade Brake Linings First-to-last

FERODO LIMITED · CHAPEL-EN-LE-FRITH *A Member of the Turner & Newall Organisation*

Factory Heating—2

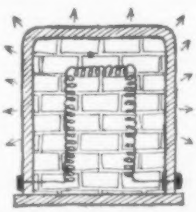
It is impossible in this Data Sheet to describe in detail every type of electric heater on the market, but a representative selection is dealt with below. Each type of building presents its own problem, and the best plan is to seek advice from your Electricity Board, who will be pleased to help.

'OFF PEAK' ELECTRIC HEATING

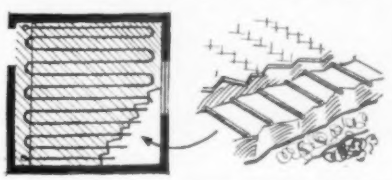
Because the 'off peak' load makes use of generating and distributing equipment when it would otherwise be idle or underloaded, it is attractive to the Electricity Boards, who offer cheap 'off peak' tariffs. Three types of 'off peak' heating systems are available, namely:

(a) Hot water storage heating: This consists of a conventional hot water radiator or panel heating system through which hot water from a large storage vessel is circulated. The water in the storage vessel is heated electrically during the 'off peak', low tariff hours and is circulated when required through the radiators or panels.

(b) Block storage heaters: These heaters consist essentially of a number of firebrick blocks which are heated up during the 'off peak' hours by means of suitable electric heating elements. The storage heaters are clad with a layer of suitable heat-insulating material and are housed in a sheet metal casing, the design being such that the stored heat is gradually dissipated throughout the day by means of radiation and convection from the casing. The great advantage of this method is that these heaters can easily be installed in existing buildings.



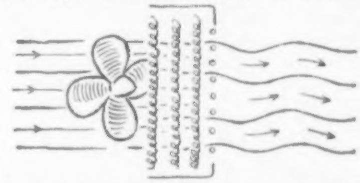
(c) Floor warming: In an 'off peak' floor warming installation, electric heating cables or ducts housing withdrawable cables are embedded in the concrete floor of the building. The cables are switched on and the floor is heated up during the 'off peak' hours, and the mass of concrete and screed of the finished floor has sufficient thermal storage capacity to heat the building during the period when current is not available. This method is only applicable to new buildings or buildings where new floors are being constructed.



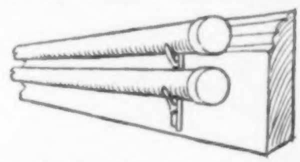
Plan view of room   Isometric view of heating cable

DIRECT ELECTRIC HEATING

(a) Unit heaters: These consist of a bank of electric heating elements fixed in a casing on which is mounted a fan which draws or blows air over the heating elements and discharges it, usually through adjustable louvres, in the required direction. A number of such units are mounted on the walls or stanchions or hung from the roof members in appropriate positions throughout the works.



(b) Infra-red heaters: These consist of heating elements usually of the sheathed metal or silica tube type mounted in a polished reflector. They operate at temperatures from 700 to 900°C, and give off the greater part of their heat output by radiation. They are mounted overhead in a similar way to unit heaters and are particularly useful for providing local areas of comfort in spaces not otherwise heated.

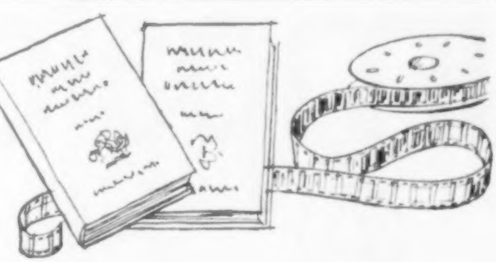


(c) Tubular heaters: These, as the name suggests, take the form of tubes approximately 2" in diameter containing an electric heating element and are available in lengths from 2 to 17 ft. The normal loading is 60 watts per foot run and the surface temperature is from 180 to 200°F. They are usually placed round the walls at skirting level, but also can be used at high level in order to prevent downdraughts from windows and skylights.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books on the industrial and commercial uses of electricity and reprints of articles and papers are available.

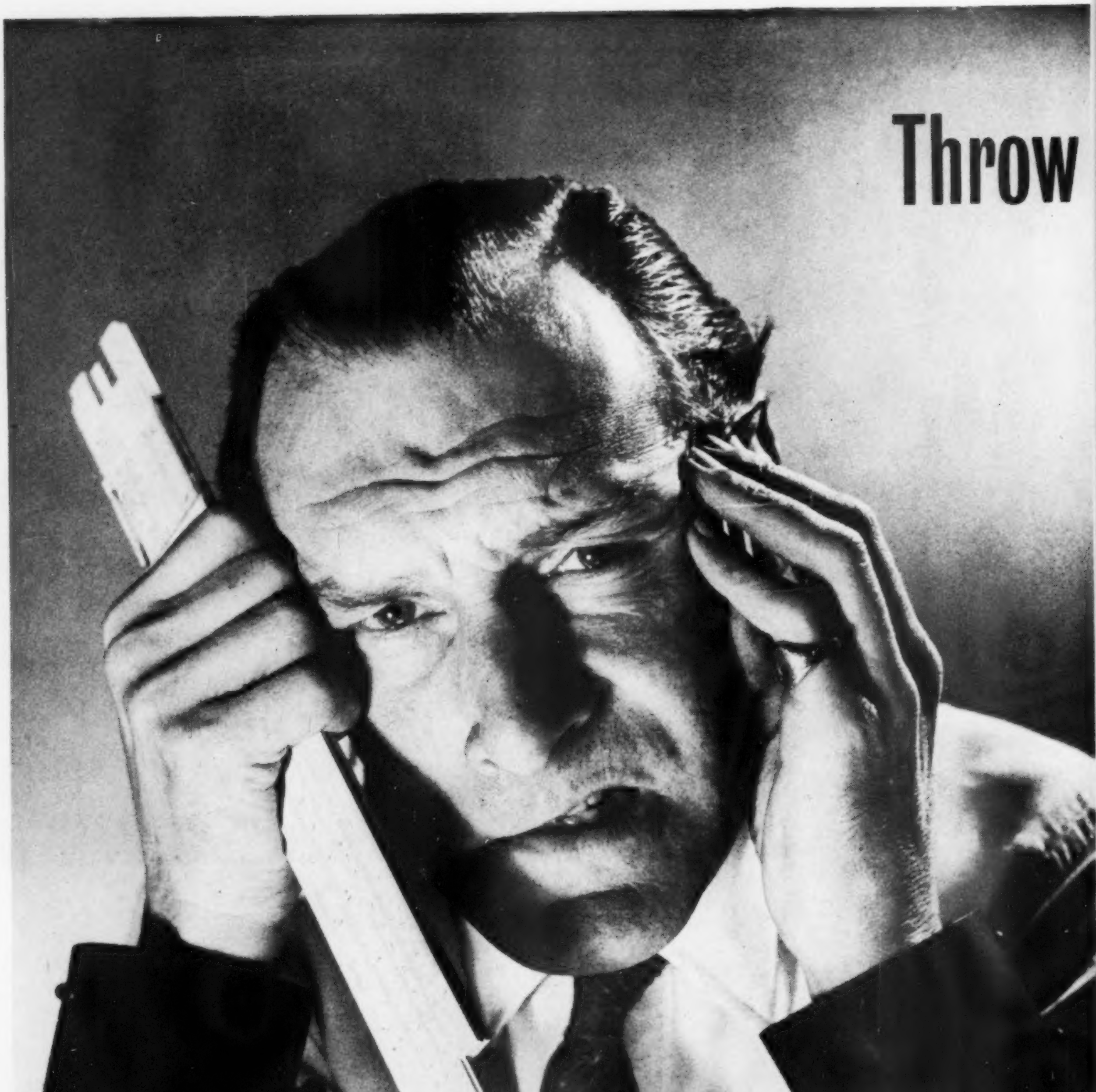
E.D.A. have available on free loan in the U.K. a series of films on the industrial uses of electricity. Film and Book Catalogues and Publications List sent on request.



CUT HERE

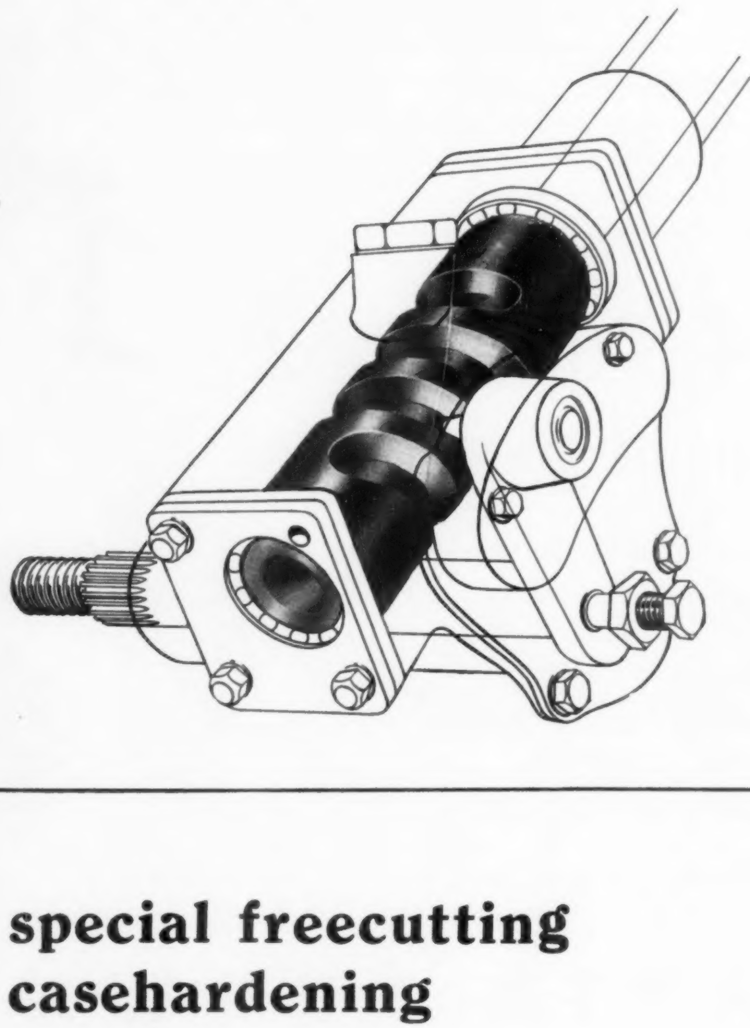
impalco aluminium

Imperial Aluminium Company Limited · Birmingham


Throw

PARK GATE

QUALITY STEELS FOR AUTOMOBILE ENGINEERING



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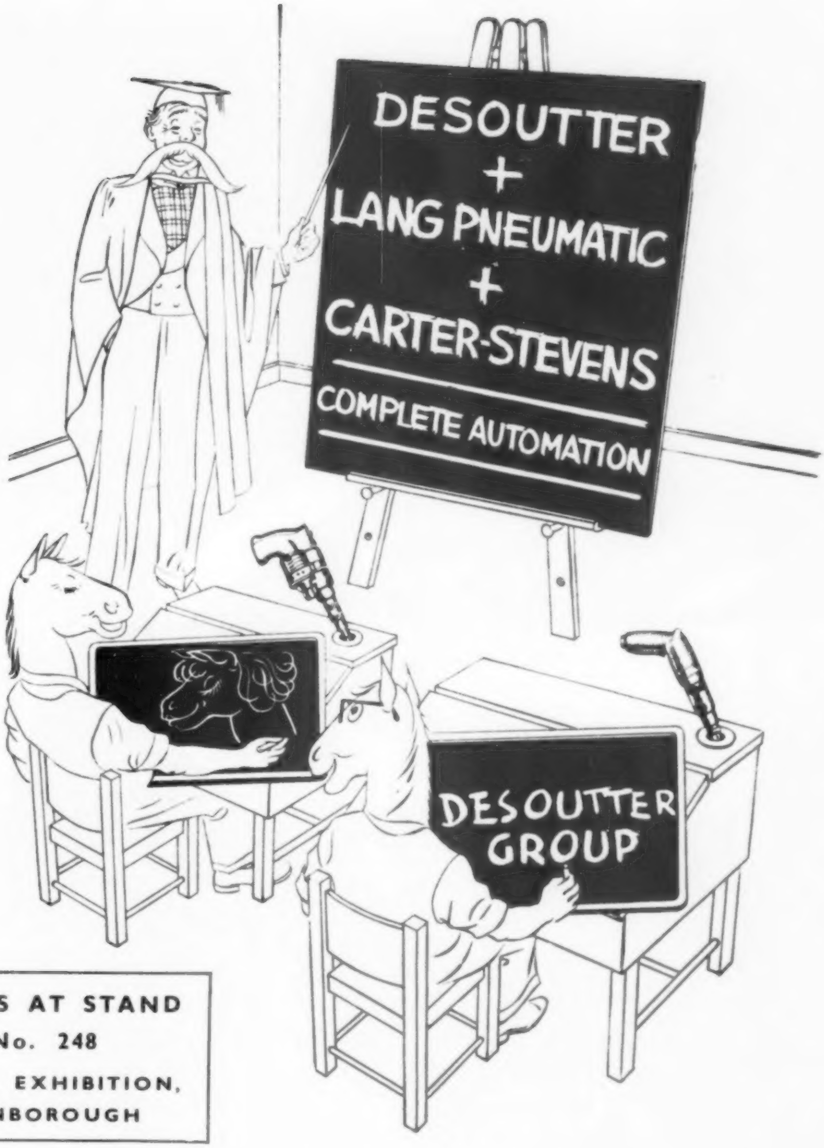
EXPERIENTIA DOCET

special freecutting
casehardening
quality bars

THE PARK GATE IRON & STEEL COMPANY LIMITED ROTHERHAM
A TI Company TEL: ROTHERHAM 2141 (15 lines) GRAMS: YORKSHIRE, PARKGATE YORKS TELEX 54141



SEE US AT STAND
No. 248
S.B.A.C. EXHIBITION,
FARNBOROUGH

"Who can tell me this?" said the M.D. with a superior smile. "If one man with one tool can tighten one nut, how many men would you need to tighten eight nuts?"

"Couldn't it be a woman, sir?" asked one Little Horse who had been reading Lolita under the desk.

"Depends whether it's at overtime rates," said the pedant of the class.

"Wrong, wrong," cried the M.D. triumphantly, "you're all wrong! The answer is NONE, because it's a Desoutter eight-spindle multiple nutrunner, controlled by Lang Pneumatic Valves and built by Carter Stevens into an automatic machine!"

"I think schoolmasters are grossly overpaid!" said one Little Horse after a long blank silence, "let's go on strike."

The Desoutter Group

DESOUTTER BROS. LTD.,
LANG PNEUMATIC LTD.,
CARTER STEVENS (AUTOMATION) LTD.,
DESOUTTER PRODUCTS LTD.

CRC/DT/346

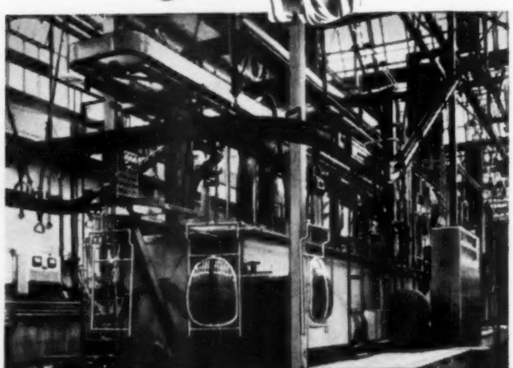

Heat treatment
Orchids grow best in the controlled heat of the greenhouse — and metal parts receive the best heat treatment in 'Cassel' salt baths.
With salt baths as with greenhouses, what counts is experience. The 'Cassel' Heat Treatment Service has long experience in carburising, heat treatment, tempering, martempering and austempering.
ICI
Write to:
Imperial Chemical Industries Ltd.
London, S.W.1.
CC.802

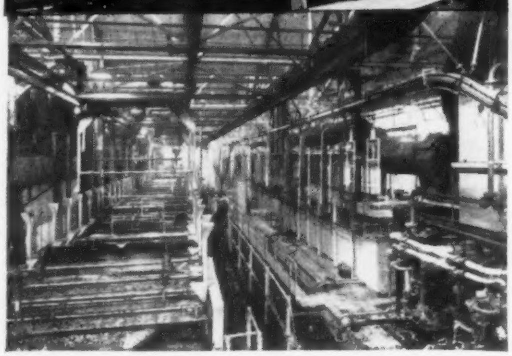
JAGUAR

use

Efco-Udylite

Plating Plant





Jaguar's high standards of plating quality on all body trim are met by two Efco-Udylite automatic plating plants and one Efco-Udylite hoist operated plant. A full description of the installation is available on request.

High temperature/high ratio chromium plating is used in these Jaguar plants to give greater corrosion protection

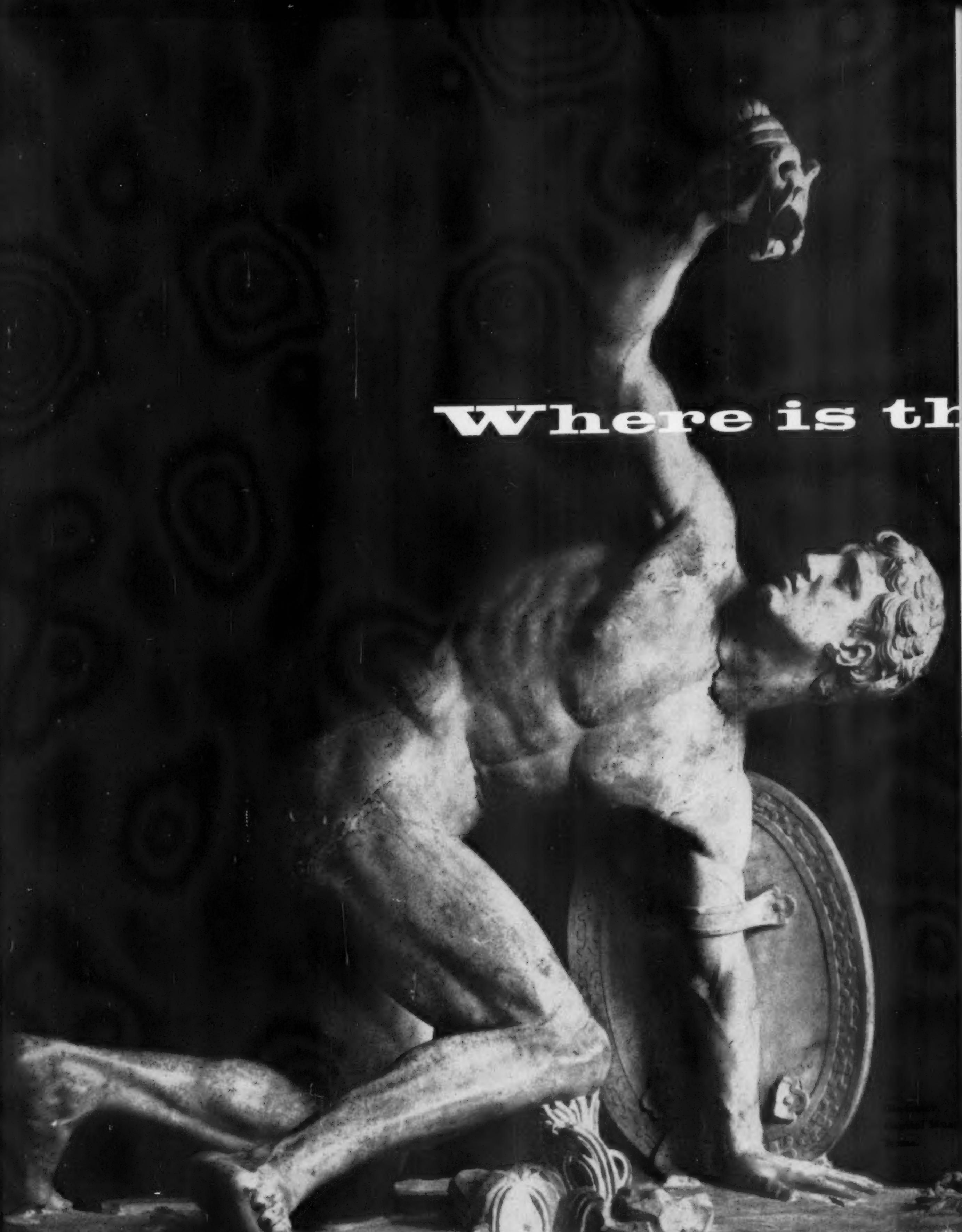
CHOSEN FOR THE FINEST CAR OF ITS CLASS IN THE WORLD

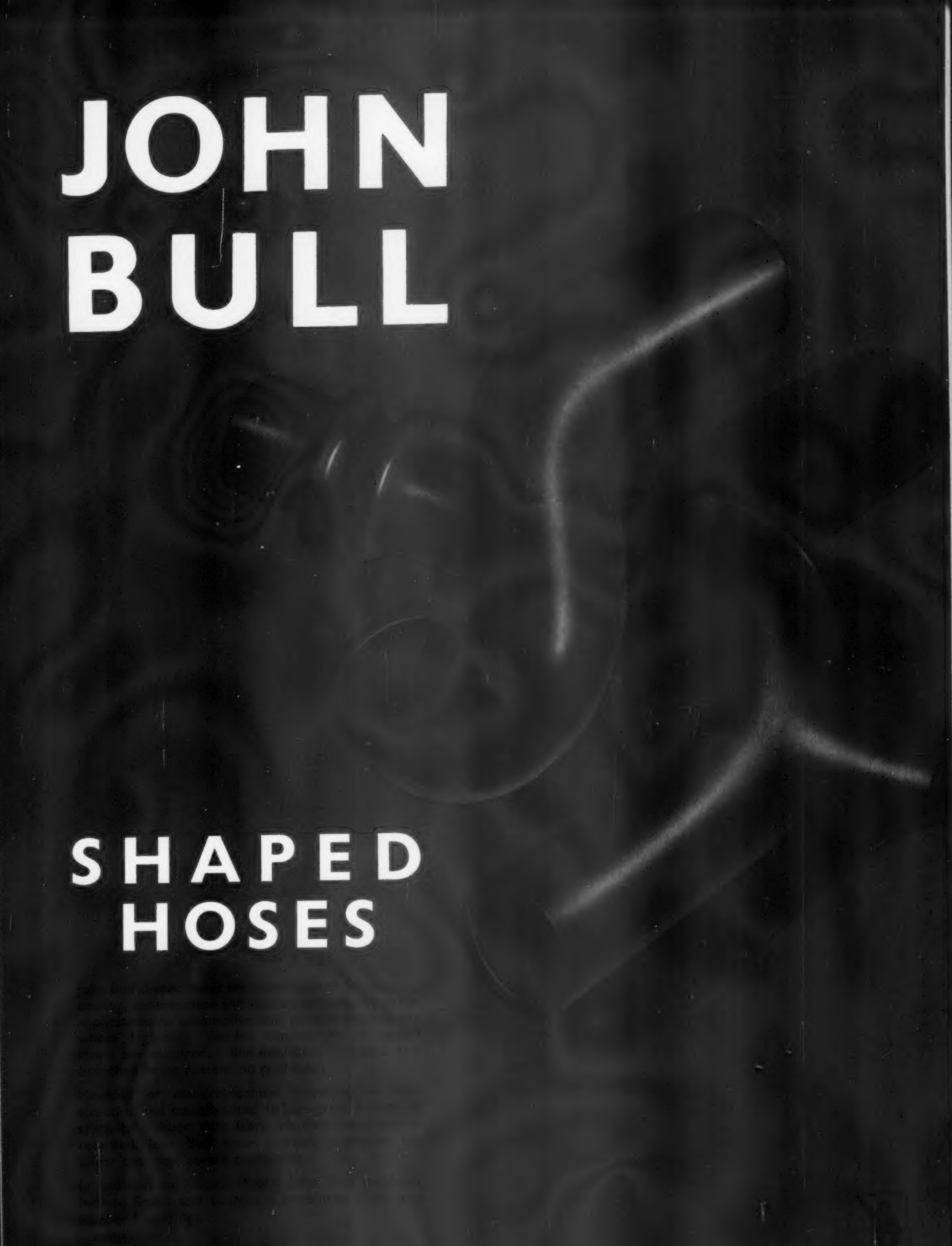
EFCO ELECTRO-CHEMICAL ENGINEERING CO. LTD.
SHEERWATER, WOKING, SURREY. Telephone WOKING 5222-7

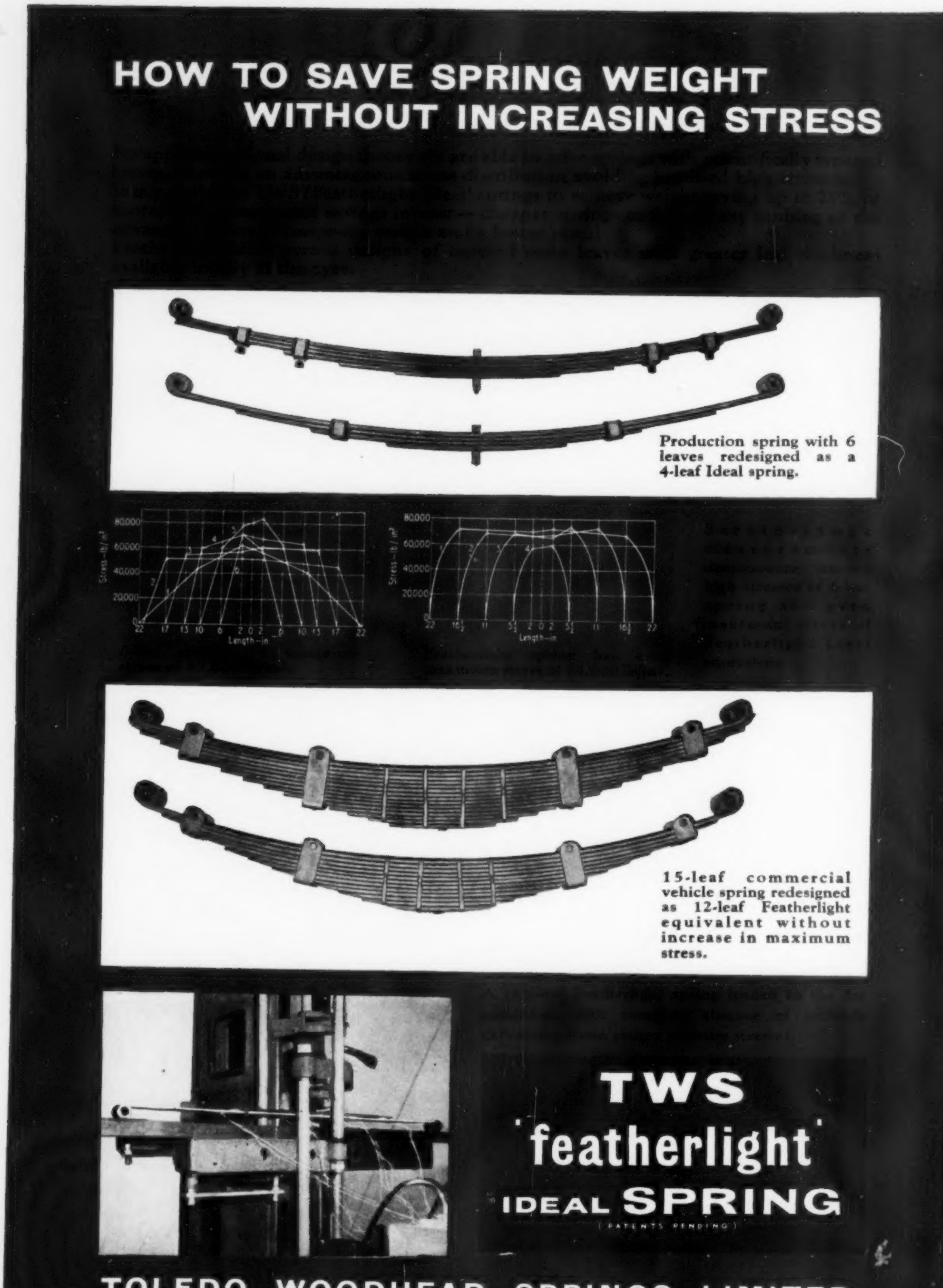
NRP 3442


Are you taking advantage

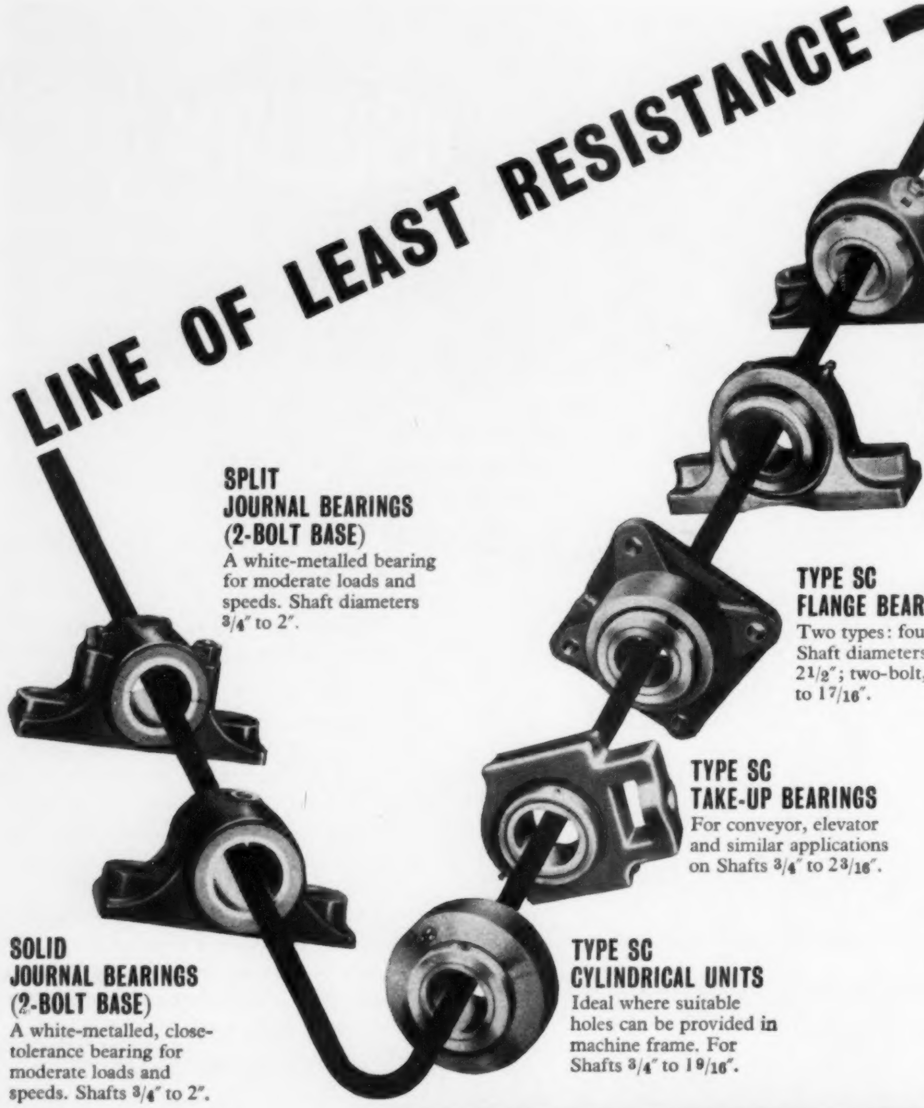
Where is th




JOHN
BULL
SHAPED
HOSES


HOW TO SAVE SPRING WEIGHT WITHOUT INCREASING STRESS
Production spring with 6 leaves redesigned as a 4-leaf Ideal spring.
15-leaf commercial vehicle spring redesigned as 12-leaf Featherlight equivalent without increase in maximum stress.
TWS
'featherlight'
IDEAL SPRING
(PATENTS PENDING)
TOLEDO WOODHEAD SPRINGS LIMITED
AYCLIFFE NR. DARLINGTON and SHEFFIELD 3

TWS 81



TYPE E WITH TIMKEN TAPERED ROLLER BEARINGS
For high speeds and heavy loads on Shafts 1 1/4" to 5".

TYPE SC BALL BEARING PLUMMER BLOCKS
For moderate loads; fully self-aligning and sealed for life. For Shafts up to 2 1/2".

SPLIT JOURNAL BEARINGS (2-BOLT BASE)
A white-metalled bearing for moderate loads and speeds. Shaft diameters 3/4" to 2".

TYPE SC FLANGE BEARINGS
Two types: four-bolt for Shaft diameters 1 1/16" to 2 1/2"; two-bolt, 1 1/16" to 1 7/16".

TYPE SC TAKE-UP BEARINGS
For conveyor, elevator and similar applications on Shafts 3/4" to 2 3/16".

SOLID JOURNAL BEARINGS (2-BOLT BASE)
A white-metalled, close-tolerance bearing for moderate loads and speeds. Shafts 3/4" to 2".

TYPE SC CYLINDRICAL UNITS
Ideal where suitable holes can be provided in machine frame. For Shafts 3/4" to 1 9/16".

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Fenner-Dodge BEARINGS

ALL ARE ROBUST YET COMPACT AND WILL GIVE LONG SERVICE IN ARDUOUS CONDITIONS

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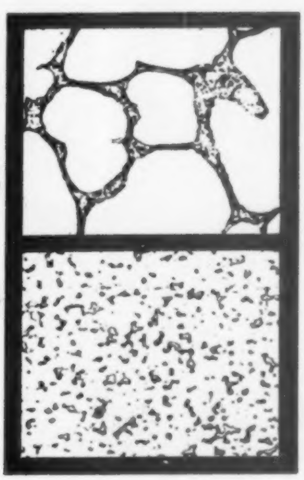
THE BEARING FOR THE SIXTIES

Glacier Reticular Tin-Aluminium on Steel

Reticular tin-aluminium, as bonded to steel for high load-carrying capacity engine bearings, is an aluminium alloy, containing 20% tin and 1% copper, worked and heat-treated so that the tin is continuous only along grain edges, but not along grain faces, as is the case when this alloy is in the "as cast" condition. Working and heat-treatment enable the aluminium grains to bond into a continuous aluminium phase whilst the tin, although not distributed over the grain faces, is still a continuous network structure.

Micrograph of aluminium — 20% tin, as cast.

Micrograph of aluminium — 20% tin, rolled and annealed.



The latest development in Plain Bearings, defined above in technical terms, offers manufacturers and private motorists—

New standard of load-carrying capacity.
Exceptional life.
Compatibility with conventional crankshaft materials.
Resistance to corrosion attacks.

It has now been adopted by—

VAUXHALL. RUSTON & HORNSBY. FODENS. PERKINS. DAVID BROWN TRACTORS. FORD. AKTIENGESELLSCHAFT ADOLPH SAURER.

Our licencees, **TRIONE** of Turin, supply **FIAT** and **S.A.M.E.** (Fratelli Cassani).

RETICULAR TIN-ALUMINIUM bearings are an exclusive product of the Glacier Metal Company Ltd., and are also marketed by their licencees.

Glacier are to supply plant of their own design and manufacture to the Russian Government for the production of Reticular Tin-Aluminium bearings for use in engines for two heavy trucks and two cars.

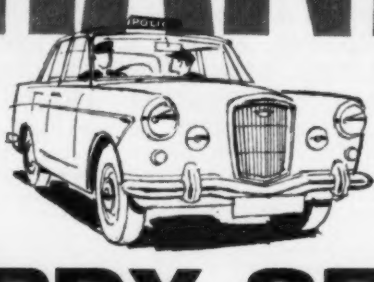
GLACIER

THE GLACIER METAL COMPANY LTD · ALPERTON · WEMBLEY · MIDDLESEX.

ON THE SPOT

IN TIME

THANKS TO



For the Fire, Police and Ambulance Services, where complete and continuing transmission reliability must never be in doubt, the automotive industry is content to place its trust implicitly in . . .

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Constant research, unceasing development — in theory and in practice — that's the key to the unremitting progress made by Girling in the service of the motor industry and in the interests of safer motoring. No effort is spared in this quest for perfection to ensure that Girling do indeed make the Best Brakes in the World.

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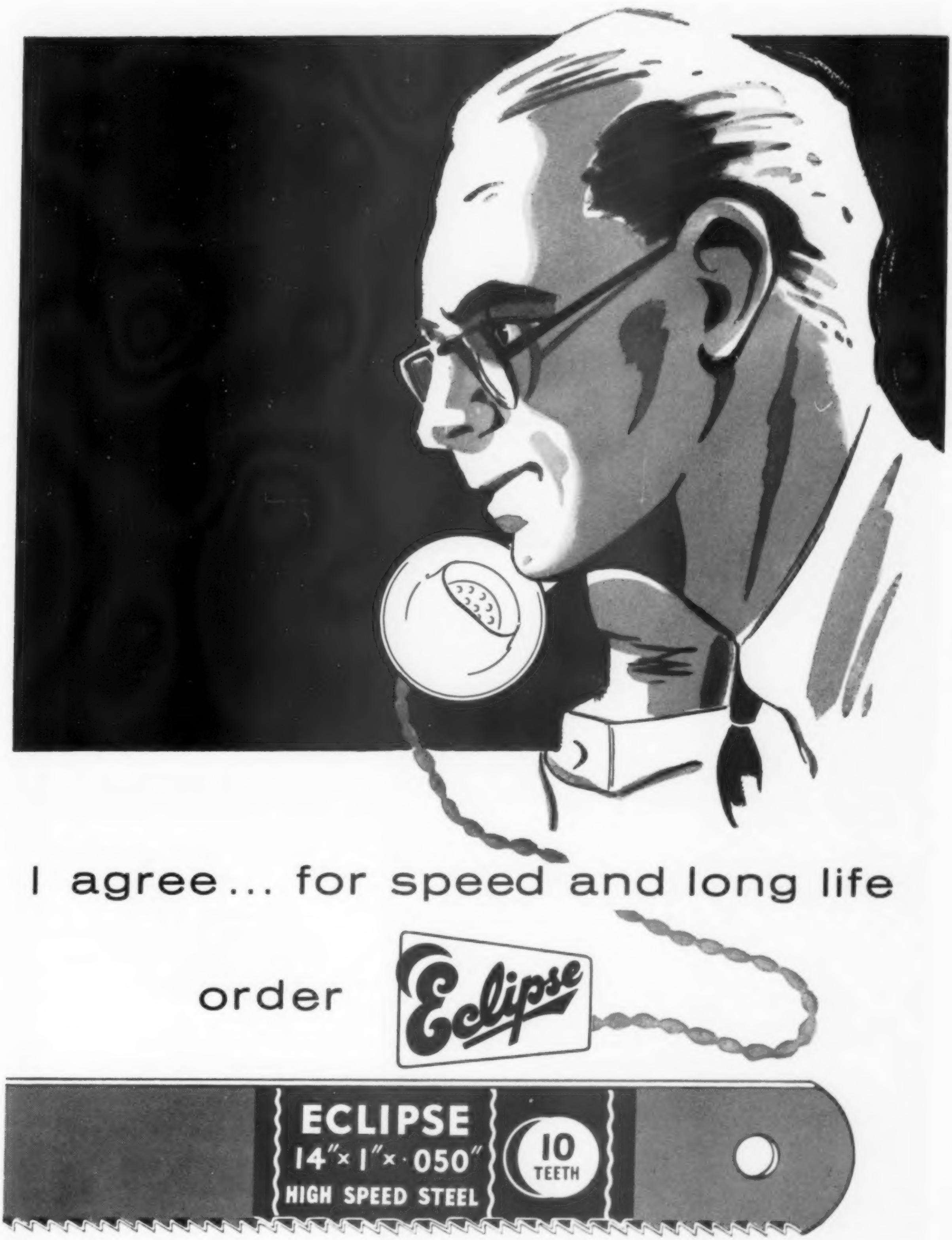
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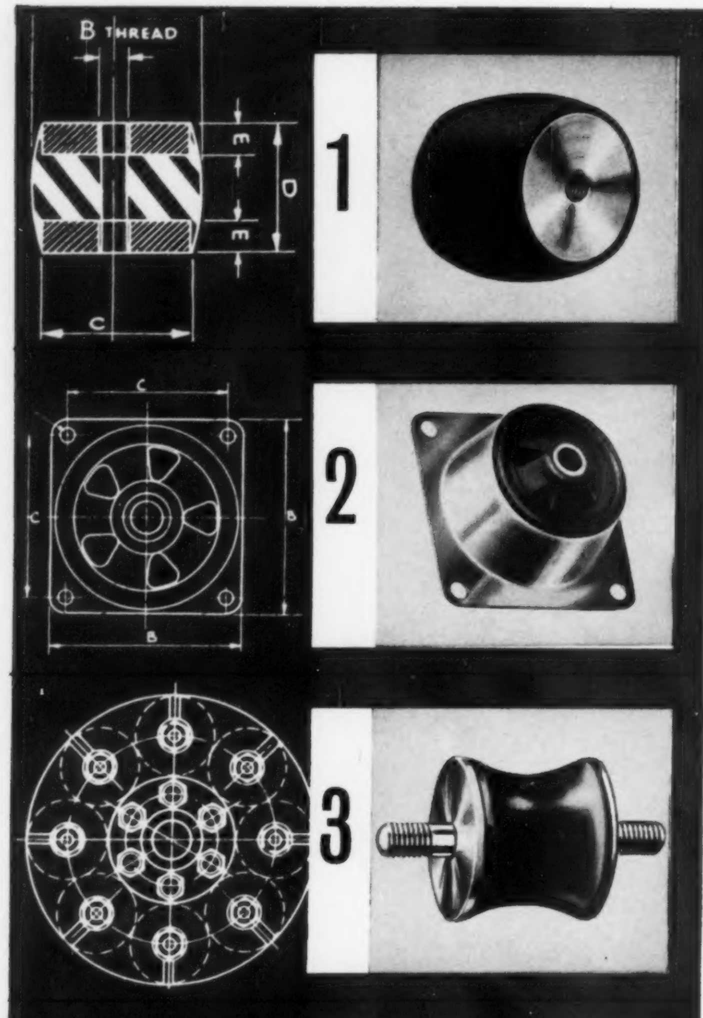

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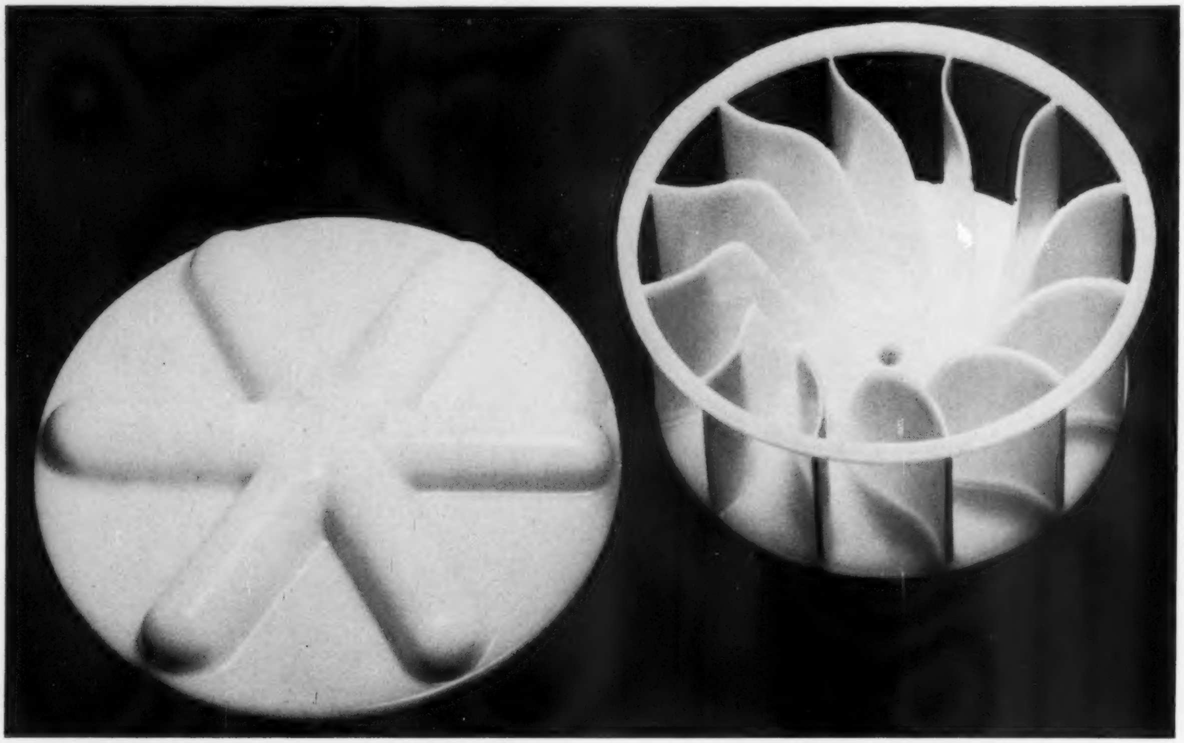

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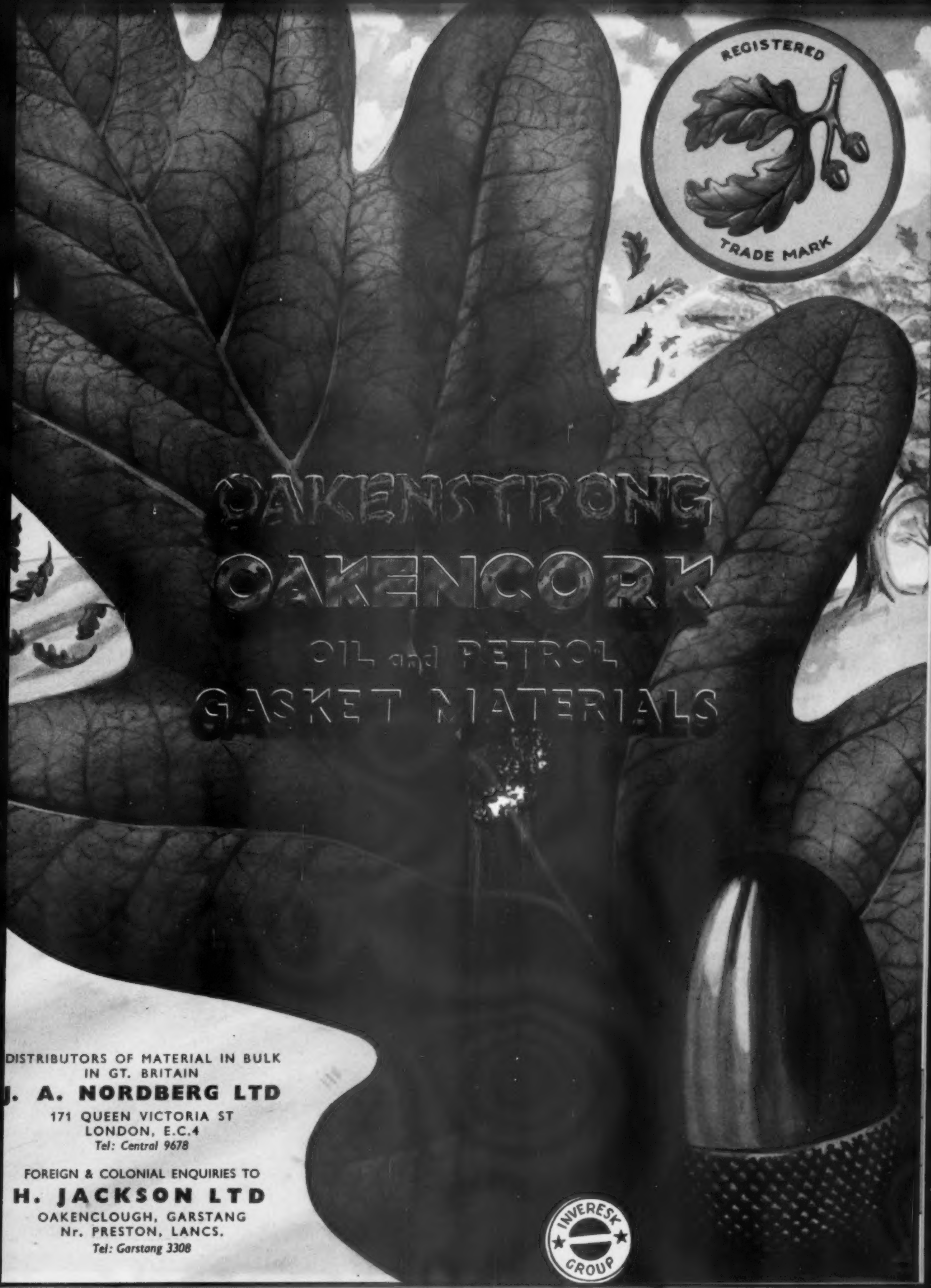
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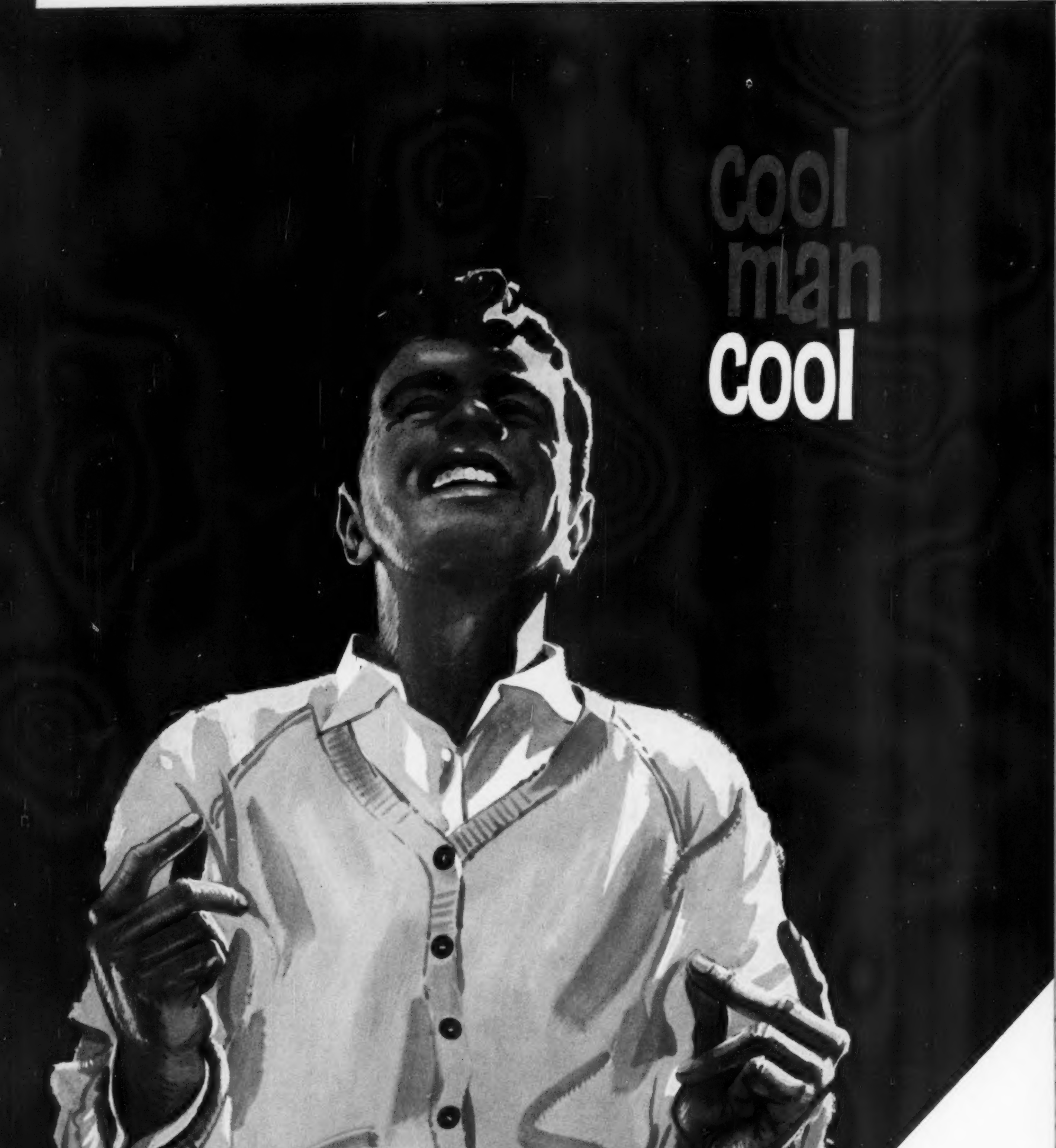
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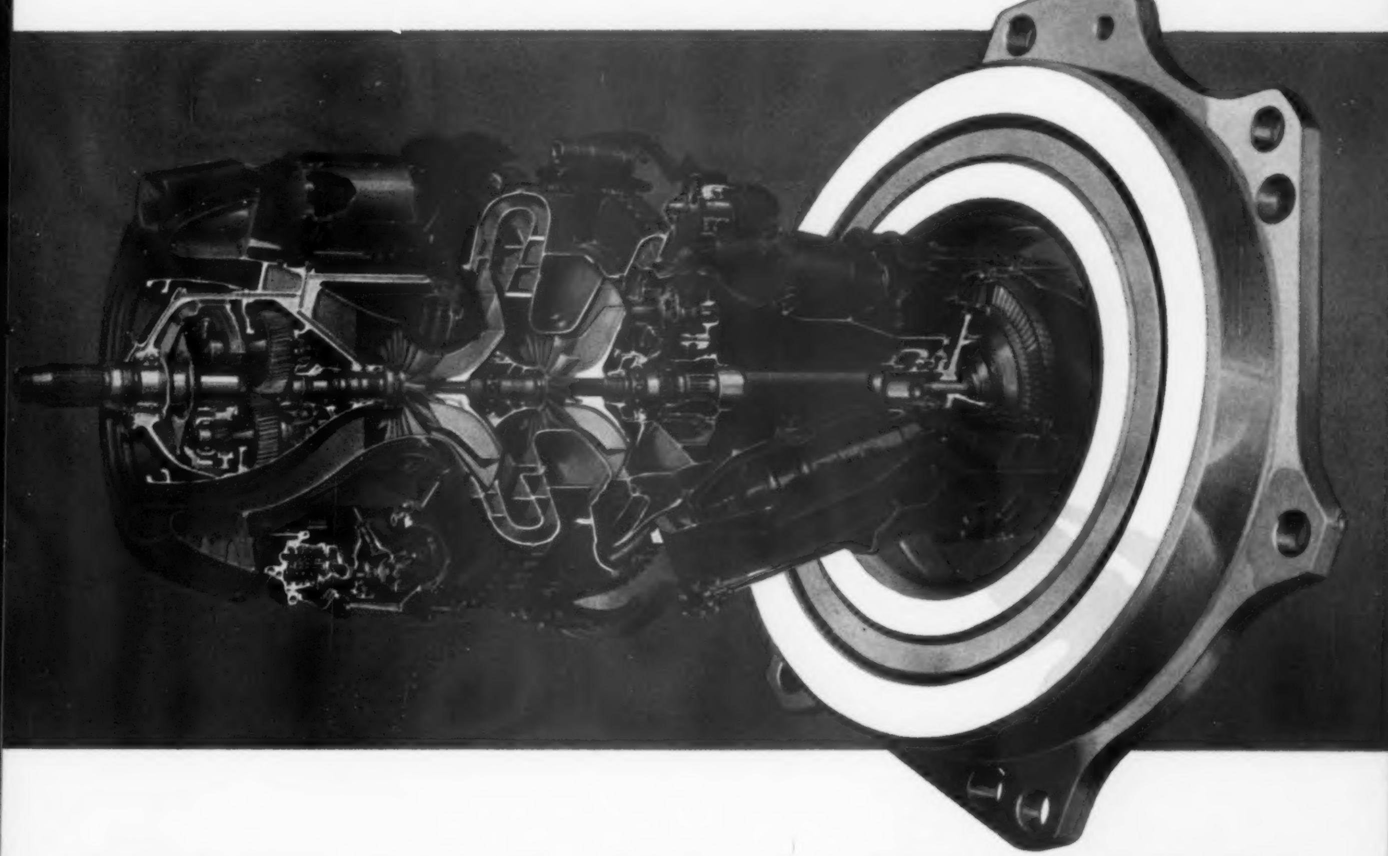

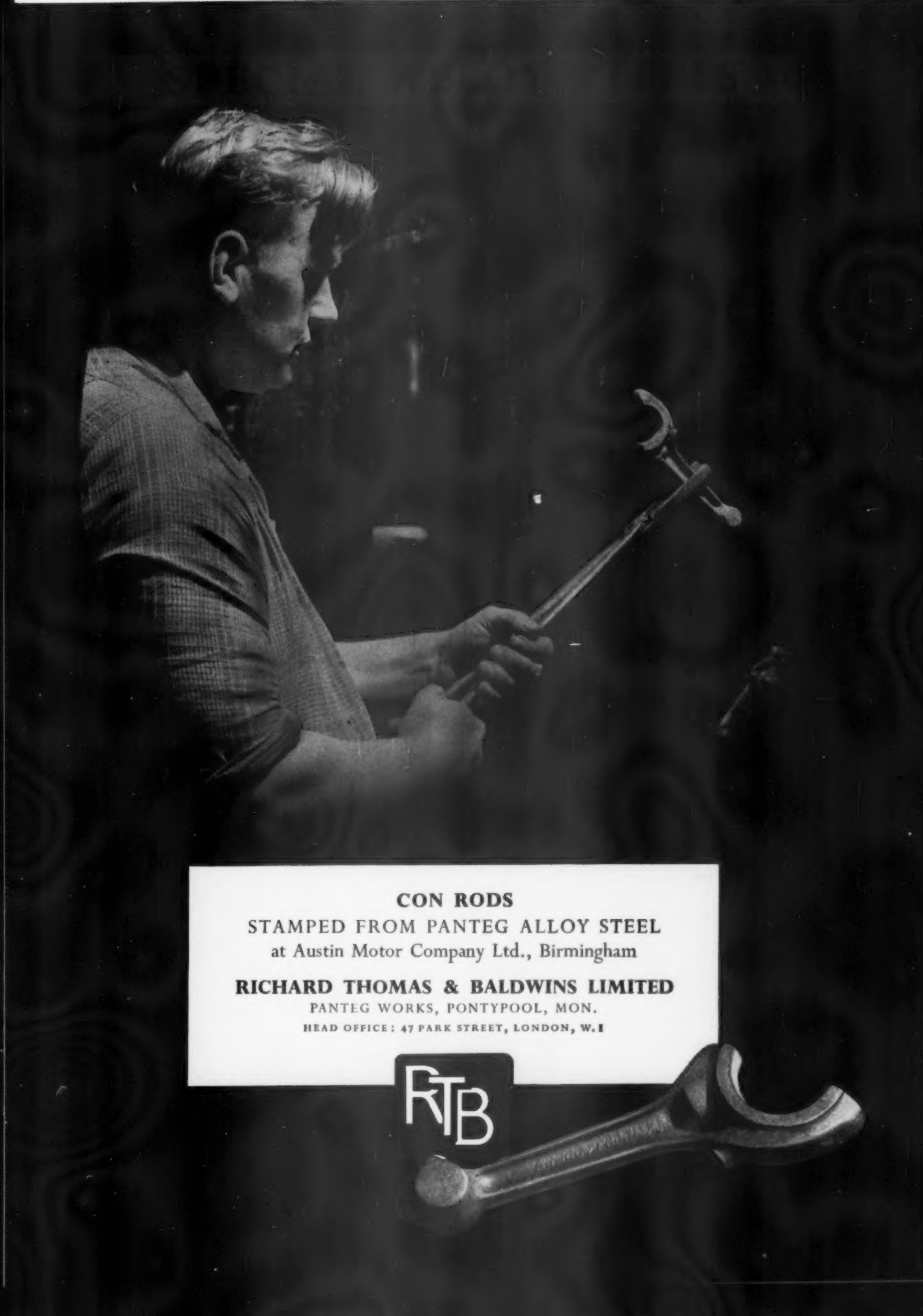

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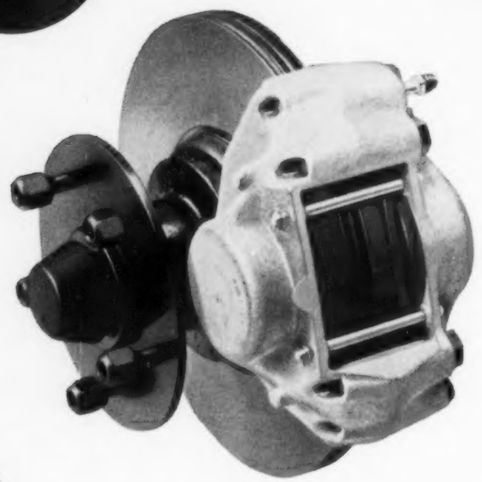

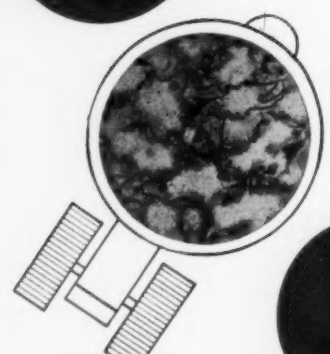

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SEPTEMBER 1961 Volume 51 Number 9

AUTOMOBILE ENGINEER

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AUTOMOBILE ENGINEER

DESIGN · MATERIALS · PRODUCTION METHODS · WORKS METHODS

Four-Wheel Disc Brakes – What Next?

WITH the recent introduction in Europe of two family saloon cars having disc brakes on all four wheels, manufacturers are in a quandary: is the demand for this arrangement likely to become so strong that they will be forced, against their better judgment, to adopt it at this relatively early stage of development? The public appear to believe that this type of brake, because of success in the racing field, is the panacea for all braking problems; and the announcements during the past year or so of a number of sports and saloon cars with disc brakes on the front wheels and drum type on the rear may have further strengthened this impression.

Obviously, therefore, unless effective steps are taken immediately by manufacturers to inform their customers throughout the world on this matter, they may find themselves faced with some difficult problems. At present, the four-wheel disc brake layout is most suitable for racing cars and, possibly, others having rear engine installations: this, of course, is because in the latter there is a preponderance of weight on the rear wheels, while in the former, there is also the low centre of gravity and therefore not so much weight transfer.

For most other types of car, disc brakes at the front and drum type at the rear will for a few years remain the best compromise. There are several reasons for this. Fundamentally, the disc type perform best at high speeds and under heavy and continuous braking, while drum brakes are best at low speeds and, even more so, in light braking: a combination of the two, therefore, caters well for both conditions. Disc brakes on all four wheels can even be dangerous in certain circumstances: for example, after a long journey at high speed, a driver, having become accustomed to the feel of the brakes under these conditions might, with unfortunate consequences, tend to use them ineffectively for lighter, check-braking in traffic in a built-up area. It should now be possible, however, to obviate this shortcoming by suitable choice of friction linings. Finally—and perhaps most significant of all—because currently available disc brakes are relatively expensive, their wider adoption depends on the development of simpler designs.

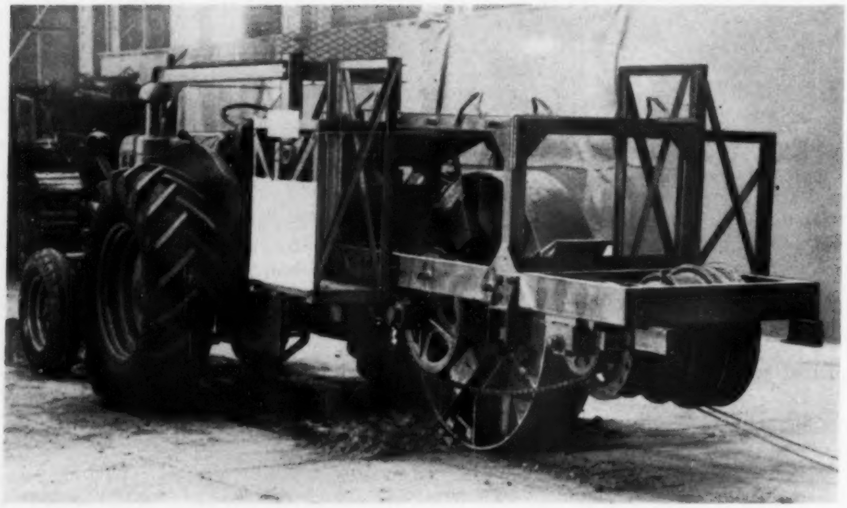
Fears have been expressed that during moderately severe braking on, for example, an abnormally long descent, the drum type brakes at the rear might fade out completely without the driver's knowledge, and then, should an emergency suddenly arise, the results could be disastrous. But if there is any tendency for the rear brakes to fade, an extra load will be thrown on to those at the front, with the result that the energy absorbed by the rear brakes, and therefore the temperatures of their drums, will tend to decrease: in other words, the condition is self-stabilizing. Secondly, a 60:40 ratio of front to rear braking is hardly adequate even as a compromise: in an emergency stop, the weight transfer to the front is so great that a much higher ratio is desirable, so fade at the rear, even if it were to occur, would actually be helpful in obviating any tendency for the rear end to break away.

There are two points, though that need to be watched in service. One is that the drum type brakes, unless a device for automatic compensation for wear is incorporated, may fall out of adjustment, whereas the disc type do not, so the vehicle may arrive imperceptibly at the condition in which only the front brakes are effective—excessive travel of the handbrake control is, of course, an indication that this has happened, unless it is masked by stretch or play in the control system. The second is that, since the disc brakes do not require any adjustment, the pads could wear away to danger point without the owner's noticing it. In such cases, if the adjustment to the drum type has in the meantime been neglected, so that the rear brakes too are ineffective, there might be no reserve at all. Fortunately, however, the squeak of steel on steel, as the pad backing plates contact the discs, is generally adequate warning.

Later, when a useful fund of experience with disc brakes has been built up, it seems likely that the disc type will become universal, at least for cars having engines of 1½ litres capacity and more. Other matters will then require attention. To help to avoid pad wear occurring at the rear when the brakes are off, special measures will have to be taken to prevent axial float of the wheel and half-shaft assemblies. Undoubtedly the problem of handbrake actuation will be overcome, but it is certain that the mechanical efficiency of control linkages, which currently is in some instances as low as 17 per cent, will have to be greatly improved. If cables, and especially sheathed cables, are used at all, very careful attention to detail will be necessary in respect of sealing and other aspects of design. Corrosion due to salt dressing on icy roads is fast becoming a major problem, and it would appear that, for the avoidance of seizure, generous clearances will have to be allowed in pivot points, plus spring loading to prevent rattling.

F.V.R.D.E.

Part I: The Research and Design Divisions and the Workshops of the Fighting Vehicles Research and Development Establishment



A test rig used by the research division, for investigating the tractive ability on soft ground of wheels equipped with spuds. The version shown here differs in certain respects from that described in the text, which is in fact a development of it

IT is self-evident that the design of a fighting vehicle of any type poses many problems not encountered in the evolution of normal road-going vehicles. Equally obviously, the special nature of the problems is attributable to differences in both the basic function and the conditions of operation. Achievement of the greatest possible degree of suitability for arduous duties clearly entails the embodiment of all the knowledge and experience previously gained in that particular field, and it is rare for any one vehicle manufacturer to possess all the relevant information. That, briefly, is the reason for the existence of the Fighting Vehicles Research and Development Establishment, at Chobham, Surrey.

Prior to 1952, the duties of the F.V.R.D.E. were divided between two departments of the Ministry of Supply—the Fighting Vehicle Development Establishment and the Fighting Vehicle Proving Establishment. Although these two departments worked in collaboration, they were under separate control. In November 1952, however, the two were amalgamated, in order to raise efficiency by cutting out any conflict of interests, and by streamlining the organization. The F.V.R.D.E. is the result of that amalgamation; it was under the control of the Ministry of Supply until 1960, when the Ministry was disbanded, and subsequently it was transferred to the War Office.

The organizational structure of the Establishment is shown in one of the accompanying illustrations. Under the Director are a Personal Assistant, a Military Assistant, a Secretary and four Deputy Directors. The Secretary is the Director's intermediary on the administration side, which is in the hands of a Senior Administrative Officer of the Civil Service. Each Deputy Director is in charge of one of the Establishment's divisions: namely, research, tracked vehicles, wheeled vehicles, and trials and development services, each of which is sub-divided as necessary.

Whereas the first three of these divisions are under civilian control, that of trials and development services—because of its concern with the functional efficiency of the end product—has a military Deputy Director, and the majority of his senior staff are Army Officers. Also, the Deputy Directors of the tracked and wheeled vehicles divisions have military assistants. For the purpose of design and project co-ordination, there is a cross-link between these two divisions.

Before the activities and facilities of the F.V.R.D.E. are reviewed, it must be emphasized that no attempt is made by the Establishment to take from the manufacturers any responsibilities that are reasonably theirs. In fact, to avoid overloading the resources at Chobham, a lot of work is put out to industry, on development contracts. Again, only prototype manufacture is undertaken in respect of components and assemblies for testing and development. The testing facilities, which will be described in Part II of this article, are fully available to the industry, and several manufacturers already use them as a valuable adjunct to those of M.I.R.A; in the case of companies in the south of England, there is of course the additional advantage of proximity.

Research division

As can be seen from the organization chart, the work of this division is divided into three main sections, namely, basic research, research on materials and applied research. The Deputy Director concerned is also responsible for the engineering test laboratories, and for research trials. Since the problems being investigated are diverse and varying, and many involve the use of equipment built for one particular purpose, this portion of the article deals only with some of the more unusual aspects of the work, and with the permanent equipment in the materials section.

One of the most interesting research projects now in hand concerns the possibility of replacing tracks by wheels. Though tracks, because of their large contact area, provide

excellent traction in mud and sand, they have serious disadvantages. In comparison with wheels, they absorb a lot of power and, owing to their exposure to abrasives and moisture, rapid wear occurs at the points of articulation. On made-up roads, too, tracks are noisy, wear relatively quickly and can cause considerable damage to the surface. The aim of the research, therefore, is at evolving a design of wheel that can equal the cross-country performance of a track while being superior to it in other respects.

For all the experiments conducted so far, wheels with rigid rims have been employed; in some instances the rims have been equipped with side flanges, and in others they have been plain. The most promising line of investigation, which is now being followed, is in connection with spuds in the wheel. It is well known that the spudded wheel can provide good traction in soft going but, in its normal form, on hard surfaces it is worse than a track. By retracting the spuds when not required, the wheel can be given good properties in both conditions. Mechanical and hydraulic methods of operating the spuds have been tried. To minimize tearing of the soil when the spuds are in use, it has been found advisable to retract them as they come out of the ground, rather than to let them project throughout the rotation of the wheel.

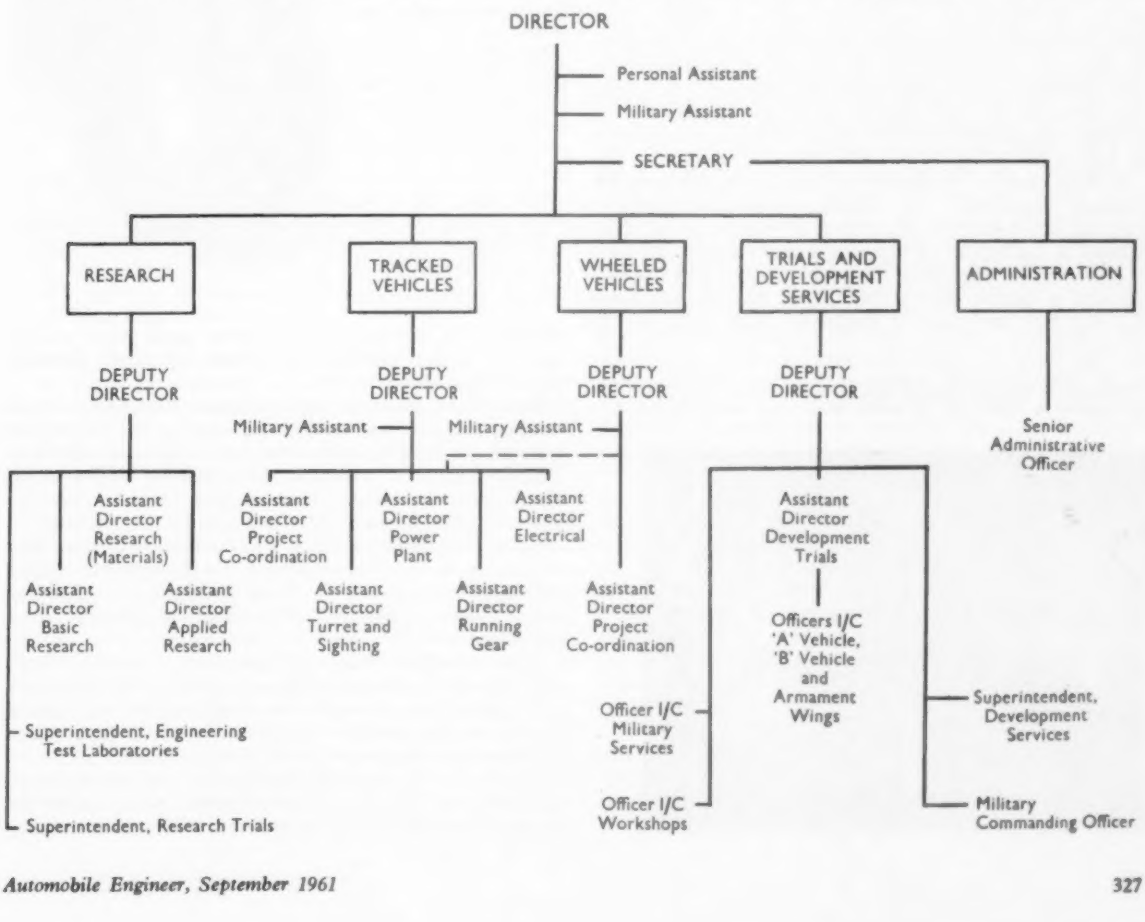
Earlier work on this project was with rigid wheels of tractor type. However, in view of the promising results obtained in a separate investigation of resilient wheels, the possibility of using the retracting spud system in these wheels is being studied. Among the important advantages expected to accrue are simplification and improved traction.

The simplification is derived from making use of the eccentricity between rim and hub to actuate the spuds. As a portion of the rim approaches the ground, the resilience of the wheel causes a reduction in the effective radius, so the spud is ejected; retraction occurs automatically as the radius increases again. Interference between the action of successive spuds is avoided by limiting their number to four or six. Since this small quantity gives rise to a jerky drive, it is necessary for the wheel to have torsional as well as radial resilience.

Various designs of resilient wheel have been investigated at the F.V.R.D.E: they include both the rubber sandwich and the rubber web types. It was found during road tests with non-spudded wheels that a considerable degree of torsional resilience resulted in a substantial increase in the effective adhesion between wheel and road. Consequently, resilience of this type should, it is thought, improve the performance of a spudded wheel. To reduce the noise, wheels used for tests on the road have a rubber facing on the rim.

Several features of interest are embodied in the test rig employed for investigating the traction characteristics of the various types of spudded wheel. This rig is shown in one of the accompanying illustrations. A parallelogram linkage system connects the tractor vehicle to the towed structure, on which are mounted a freely rolling drum and the test wheel; a screw-jack levelling arrangement ensures that the tractor pull is applied horizontally to the structure. As the drum revolves on the ground, it also rotates the test wheel by means of a chain drive between them. However, since the effective ratio of the drive is less than 1:1, the wheel is forced to slip, by a fixed proportion, relative to

This chart shows the organizational structure of the F.V.R.D.E. Each of the four technical divisions is in the charge of a Deputy Director



the drum. The tractive ability of the wheel is indicated by its resistance to slip, which is measured by a ring strain gauge. Another strain gauge is used to measure the cam forces necessary to retract the spuds.

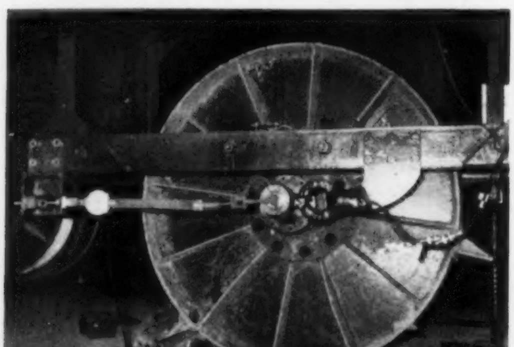
An intrinsic part of the research on traction in cross-country conditions is the investigation of the cohesion and compacting characteristics of various types of soil and other surfaces. These properties are studied at the F.V.R.D.E. by the use of Evans vane type testing devices. Like other vane testers, the Evans device consists of two vanes set mutually at 90 deg on the end of a shaft. The vanes are inserted in the soil and the shaft is twisted, the torque necessary to shear the soil being measured directly. Since the size of the vanes is known, the shear strength of the soil can be determined.

Because of the influence of vibration on the life of components, and hence on the reliability of a vehicle, vibrational analyses are frequently carried out on vehicles of all types. For this purpose, variable-induction accelerometers are employed, and their responses are recorded electronically. The accelerometers are mounted in groups of three, at various points on the vehicle. Those of each group are set mutually at right angles, to respond to longitudinal, lateral and vertical oscillations. Any vibrations with a frequency lower than 100 c/sec can be accurately analysed. With a view to detecting resonances, vehicles under test are driven at all speeds up to the safe maxima for the various types of terrain concerned. The possibility of harmonic vibrations occurring is investigated by operating additionally at multiples of those speeds at which major resonances are experienced.

The main purpose of the Establishment's research on materials is, of course, to ensure that these are adequate for their particular duties. As a general rule, the aim is at ensuring that each component will remain serviceable for the overhaul period of the assembly of which it forms a part. If an unnecessarily high grade of material is used, difficulties are likely to be experienced in respect of machineability, heat treatment or welding during manufacture. It follows that much of the work done is of a *post mortem* nature, investigating failures that have occurred either in service or on test.

A wide range of equipment is installed in the materials research department: it includes analytical apparatus, furnaces, test machines and a variety of welding plant. Steel analysis is carried out by means of a spectrograph and combustion carbon apparatus, and the metallography section contains a Vickers microscope. Three furnaces are available for heat treatment of specimens; they range in size from a small muffle type to quite a large Wild-Barfield unit.

In the test rig depicted on page 326, the resistance of the wheel to slipping is measured by means of a ring strain gauge



One of the more impressive machines is the Ballinger wet slitter used to cut off test pieces of armour plating and of other hard components. This slitter carries a 26 in cutting wheel, and in operation it does not cause any substantial temperature rise in the material being cut. Consequently, the exposed surfaces of hard specimens are not softened by the cutting operation. In the testing laboratory are an Avery 30-ton universal machine, Izod and Charpy impact machines, a Vickers hardness tester and a small machine for torsional fatigue tests.

Although the welding section deals with other metals, the bulk of its current activities concerns armour steels. Specifications of these steels have now become fairly stabilized, but the search continues for greater hardness without embritlement; the aim is, of course, at reducing the weight of armour necessary for any particular duty.

There are two arc welding generators—an Actarc for a.c. and a Lincoln for d.c.—and Cyc-Arc stud welding equipment. Argonaut and tungsten arc plant is also available, the latter being mainly used for aluminium and titanium. If welded joints are to be used on the armour of a fighting vehicle, it is clearly essential for the welds not to be a source of weakness. This means that both the electrode material and the welding techniques must be satisfactory. Special tests are therefore used to determine the reliability of the joint produced by any particular electrode and method. One of these is the R.D. rigid butt weld test, so called because it was evolved by the Research Department, Royal Arsenal,

Among the resilient wheels that have been investigated is this Dunlop assembly. It incorporates bobbins of rubber, which are bonded at their ends to attachment plates

Woolwich; in this test, two 12 in × 6 in specimens of armour are butt welded together, side by side, using the electrode under investigation.

In the preparation of the specimens, the middle 6 in of one edge of each is given a 60 deg chamfer and the two are clamped for welding on a steel base 1 in thick. Between them and the base, except in the immediate locality of the weld, is inserted a layer of paper about 0·007 in thick, to act as a heat barrier. The vee between the chamfers is filled in four welding runs, in alternate directions, after which the assembly is allowed to stand—with the clamps still tight—for 24 hours. Then the clamps are removed and a further period of three days is allowed before examination.

If the visual and microscopic examination specified reveals any signs of cracking, the test is repeated with specimens 4½ in wide. In this case, the conditions are less severe, because of the reduced constraint of the narrower plates, and because the smaller heat reservoir results in higher temperatures. If this joint also fails, a third test is carried out with 3 in wide pieces. An electrode that passes the test on the 6 in specimens is considered to be satisfactory for

The compacting characteristics of soils are investigated as a necessary part of the research on traction phenomena. One of the machines employed is this Howard compactor, which is of the dropping-weight type

armoured vehicles. One that fails the 6 in tests but passes at 4½ in is regarded as borderline, and its suitability has to be verified by other means.

Special precautions have to be taken in the preparation of the electrodes used for welding the armour. The normal type of austenitic electrode must be preheated for an hour at 110 deg C and used immediately on removal from the preheating cabinet. A new type of ferritic electrode, on the other hand, has to be heated to 500 deg C for the same period, to dry out the coating. It can then be stored in the cabinet at 110 deg C, but must be used immediately on removal. If the coating is not dried out in this way, the quality of the weld is likely to be impaired by the development of cracks.

Lubricants and special components are tested on project vehicles by the trials and development services division, though these tests are carried out under the control of the research division. No actual research on lubricants is carried out at Chobham, but expert advice is obtained from another branch of the War Office, and on occasion the oil companies are called in to discuss particular problems. Any special lubricants that are necessary are evolved and initially tested by those companies before being submited to the F.V.R.D.E. The same sequence applies in the case of plastics materials, which are being increasingly applied in a variety of application on fighting vehicles.

Vehicle design and project co-ordination

As would be expected, the evolution of fighting vehicles necessitates an enormous amount of design work, and this work is by no means of a regular nature. In consequence, the design departments of the Establishment, although extensive, are not intended to deal with all the detail matters. However, they are responsible for the basic designs and the control and checking of the other work, which is done by the civilian companies responsible for building the complete vehicles, components or equipment.

Wheeled and tracked vehicles are each the responsibility of a separate division, because of the fundamental differences in the problems involved. However, in respect of actual fighting vehicles, the procedure of the two divisions is virtually the same. Before this is described, however, it is perhaps appropriate to mention the alternative policies that apply regarding the sale of the various types of vehicles to other countries, once the requirements of the British armed forces have been met. These sales, which have considerable prestige value and reduce costs by increasing the production run, are negotiated either by the manufacturing company concerned or on a government to government basis, according to the type of vehicle concerned.

The design of a new fighting or tactical vehicle of either the tracked or wheeled type for the Army originates in a weapons policy statement prepared by the General Staff. As a result of this statement, the War Office produces General Staff operational requirements, which are subsequently amplified in a technical document, known as *Military Characteristics*. This document is the formal basis on which the F.V.R.D.E. undertakes the project, though it will, in fact, have acted in an advisory capacity from the inception of the policy.

On receipt by the Establishment of the *Military Characteristics*, the feasibility of the proposed vehicle is investigated in every aspect, and any necessary design studies are put in hand. As the scheme grows from these investigations, the design essentials are committed to paper. The next stage is for the basic layout to be approved at a meeting with the War Office and the intended user, after which the detail design is commenced, sometimes at Chobham but more usually by a company selected by virtue of its experience and capacity for the ultimate manufacture of the vehicle. This company, which is known as the design parent, enters a contractual agreement with the F.V.R.D.E. for the work it is to undertake. However, this agreement does not extend beyond the prototype stage of the vehicle: the War Office reserves the right to place production contracts as a result of open tender, though favourable consideration is always given to the design parent. If the necessary capacity is available, one or more of the Royal Ordnance Factories may be awarded part of the production contract.

When the detailing is sufficiently advanced, a wooden mock-up of the vehicle is constructed. It will readily be appreciated that this mock-up serves a most valuable function. Since all the main assemblies and components are accurately represented on it, the various spatial relationships can be assessed, as can such matters as the disposition of the crew as a fighting team, fields of vision, stowage of ammunition and special equipment, and ventilation. The mock-up is closely studied by a panel, which again includes representatives of the intended user, the General Staff and the Establishment.

Assuming that no major objections are raised by this panel, the design is conditionally accepted, after which the design parent completes the detailing and builds prototypes for development trials. During all stages, the F.V.R.D.E. gives the company's design and constructional departments

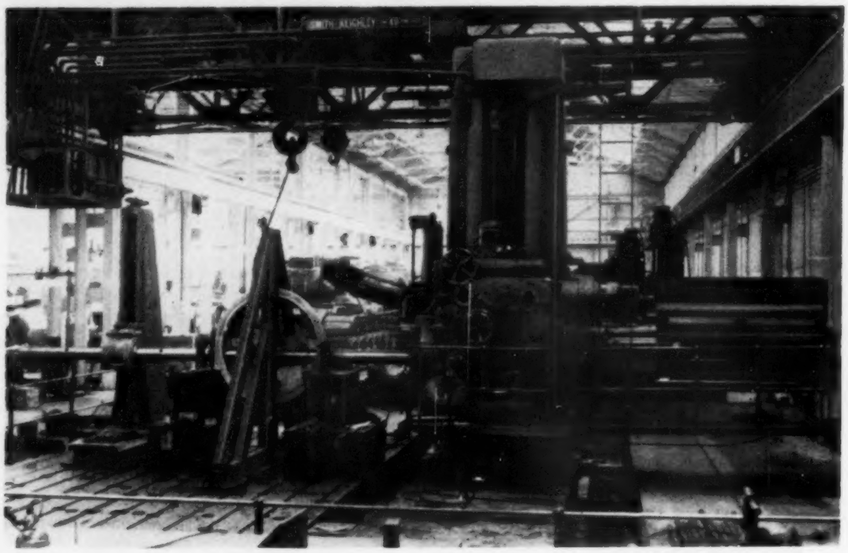
whatever guidance and assistance they need; any such assistance is co-ordinated through the engineer responsible for the project, who is supported by the various specialist branches in respect of such items as the power plant, running gear, armament and armour, radio and electrical equipment. It is worthy of mention that the relations between the Establishment and the industry have always been very harmonious.

The number of prototypes built varies: it is never less than two, and for a complicated vehicle such as a tank it may be as high as six. Normally additional prototypes will be ordered for user trials by service personnel, to be carried out after the Establishment has proved the initial group, and sometimes a pre-production batch is built for troop trials. The quantities in each of these cases depend on the type of vehicle: the greater its versatility and complexity, clearly, the larger is the number, to enable all the possible conditions to be investigated. For troop trials the quantity might be between 10 and 50.

The prototypes are delivered to Chobham for their trials, the nature of which again varies with the complexity of the vehicle. In the case of an armoured wheeled vehicle, one prototype would undergo automotive proving trials to determine its reliability and characteristics as a vehicle. Another would be given functional tests to assess its fighting abilities, and a third would be used for the investigation of climatic effects. If the vehicle were a tank, at least two prototypes would be employed on automotive development running, another on the testing of the electrical equipment, another on engine cooling investigations and another on development trials of the complete gunnery and fire control system. Because these vehicles have to be suitable for operation anywhere in the world, including the tropics and arctic regions, the effects of very high and very low temperatures must be studied. To avoid the monopolization of a complete vehicle for a lengthy period, therefore, a separate hull portion is built, containing the complete power plant, and is tested as necessary in both the high-temperature and low-temperature laboratories.

For the functional and automotive trials, schedules are prepared by the project co-ordination branch in co-operation with the appropriate specialist branches who may also issue test schedules to cover their particular interests. In assessing the performance over various types of terrain, use is made of reference vehicles of established design. Large mileages are covered on the test tracks to prove the reliability of the vehicle and installed equipment. Road running is also undertaken to ascertain the behaviour in traffic and the suitability for driving at night and in convoy.

Special attention is, of course, given to the protection afforded by the armour against gunfire from all angles, including overhead bursts, and from mines detonated by the vehicle. The shock testing of components and their mountings, too, is very important. It is essential, for example, that a hit should not result in jamming of a hatch as a result of the shearing of the bolts or fracture of the internal brackets. Other factors to be studied include maintenance, the ability to withstand long periods of storage, and the practicability—in terms of weight and dimensions—of transportation by air.



This Asquith horizontal borer is one of the most impressive machines in the workshops. The space it occupies is large, to enable complete vehicles to be brought to it for work such as the final boring of the pivot bushes for the suspension arms

Once the testing of the prototypes is well advanced, and the Establishment is assured that no fundamental faults exist, it is usual for either a prototype or an early production vehicle to be sent to Canada for arctic trials, and another to Australia for corresponding tropical trials. These additional trials are carried out with the assistance of the armies of the two countries, under the guidance of a project officer from the F.V.R.D.E.

After the satisfactory completion of the Establishment's and user's trials, but while the overseas climatic trials are still in progress, the relevant reports are written up and discussed at a meeting of all the interested parties, after which the vehicle is conditionally accepted on behalf of the Army by the General Staff Director of Equipment Policy. The design is then modified to embody any improvements agreed at the discussion, and the production drawings are prepared. Meanwhile, the manufacturing specification is written at Chobham, in consultation with the design, production and inspection branches.

If, as is almost inevitable, difficulties are encountered on going into production, the manufacturer can approach the F.V.R.D.E. with requests for assistance, or perhaps for permission to make minor changes. When the first production vehicles have been completed, it is customary nowadays

for a project officer to accompany them to the theatre of operations to explain the functioning of the vehicle to the users and to deal with any further snags. Thereafter, the Establishment provides what is known as technical support —mainly the investigation, in conjunction with R.E.M.E, of defects of design or manufacture, and the institution of modification procedure where necessary.

The wheeled vehicles division is responsible for the General Service range of vehicles as well as the fighting and tactical types. In the evolution of a General Service vehicle, the initial procedure—as far as the publication of the *Military Characteristics*—is as before. Subsequently, however, no mock-up is built; instead, a detailed technical specification is prepared and is then discussed with suitable and interested companies in the industry. The purpose of the discussion is to determine how any particular firm's standard chassis could best be adapted to meet the specification. Since this document lays down desirable as well as essential requirements, there is room for compromise in many respects. Prototypes are built and tested and the subsequent procedure is as already described.

As a result of these tests and subsequent tenders, one company is selected for the supply of all chassis in a particular load class for a period of five years. This provision, which is, of course, subject to contractual safeguards, is made to ensure adequate production quantities and the standardization of spares.

Each General Service chassis is intended to carry any one of a wide variety of bodies. Normally, each type of body for a new vehicle is the subject of a study at Chobham, after which a detailed technical specification is prepared to permit the design and construction of prototypes by the selected design parent company in the body building industry. The widest scope for competitive tendering for the production contracts is given by basing the design of each body on commonly used methods of production.

The specialized equipment needed for these vehicles is as varied as the bodies. Whereas the design and suitability of any particular item is the responsibility of the supplier selected by tender, the F.V.R.D.E. carries out acceptance tests both in the laboratory and *in situ* in the vehicle concerned. Further reference to the laboratory testing will be made at a later stage, in the second part of this article.

Finally, there are the various non-fighting, special purpose vehicles, which may be of the wheeled or tracked type. These include recovery vehicles of various sizes, tank transporters, aircraft salvage vehicles, tankers and carriers for guided weapons. In cases where a special purpose vehicle is completely new, the procedure adopted is identical with that for a fighting vehicle; if, on the other hand, it is an adaptation of a manufacturer's existing product, the same system is employed as for a General Service model.

The foregoing is a necessarily brief summary of the function and methods of the vehicle design branches of the Establishment. In addition, however, mention should be made of the specialist branches, which constitute quite a large section of the F.V.R.D.E. There are four of these branches —Running Gear, Power Plant, Electrical, and Turrets and Sights—and they are responsible for the design and development of the appropriate major assemblies of the fighting vehicle. Their method of operation is similar to that described in connection with the complete vehicle, in that they carry out the initial design concept of equipment to meet the military requirements. Once the branch concerned is satisfied with the general scheme, the development and manufacture of prototypes is carried out by firms working under contract. A wide and varied field is covered, of which only the barest outline can be given here.

The Running Gear branch is responsible for all transmissions, brakes, final drives, tracks and suspension systems. Among its major tasks has been the introduction of automatic transmission systems for large armoured vehicles. As the name implies, the Power Plant branch deals with the whole of the engine compartment. This branch has been very active lately in pioneering the development of multi-fuel engines, and has sponsored a range of opposed-piston, two-stroke engines of high power and light weight, capable of operating on 80 octane petrol or on diesel fuel. Radiators, fans and heat exchangers are but a few of the items developed.

Owing to the increasing use of electrically operated components in armoured vehicles, the Electrical branch is concerned with a remarkably large number of components. These include electronic control equipment for tank guns; large-output generator systems, both a.c. and d.c; engine starting systems, including batteries for low-temperature

A view of part of the tank workshop, in which is executed a variety of work on tracked vehicles. Any prototype building to be done by the Establishment is carried out there, as are the modification of the prototypes already undergoing trials and the construction of test rigs and mock-ups

operation; also searchlights and wiring installations. In the Turrets and Sights branch is undertaken the design of gun turrets, including the gun mounting and recoil system. It will be appreciated that the design of a turret imposes many problems, because the unit has not only to withstand attack from opposing armaments but has also to provide accommodation for the very large amount of necessary equipment, among which is a complex optical sighting system.

Workshops

As can be seen from the plan, the workshops form a part of the trials and development services division. However, because in the evolution of a new vehicle they play an earlier part than do the other sections of that branch, it is appropriate to review them at this juncture, and to cover the trials work later. The workshops are under the command of a Lieutenant-Colonel but are manned almost entirely by civilians. In effect, there are two internal departments, one dealing with production matters and the other with vehicles. Both have their own progress and costing offices.

In connection with production, an extremely important role is played by the pattern making and carpentry shops. As was mentioned earlier, one of the first stages in the evolution of a tank or other tracked vehicle is the building of a wooden, full-scale mock-up, for investigations into the practicability of the proposed layout. The main questions to be answered are whether all the necessary equipment can be accommodated and whether, in that event, the vehicle can be operated efficiently. It follows that all possible details—including interior and exterior form, power unit and controls, armament and ancillaries — must be reproduced to a high standard of accuracy.

Once the basic design of the vehicle has been approved, many of the production drawings are prepared from this mock-up. Additional mock-ups are frequently employed during the development stage, mainly for the investigation of proposed alternative layouts or modifications to extend the scope of the vehicle. For such purposes, it is clearly both quicker and cheaper to use wood than metal.

The workshops contain a small tool room, which, in addition to its normal function, also does any fine machining beyond the scope of the main machine shop. As well as the normal machine tools, the toolroom equipment includes a very accurate jig-borer, and aids to precision such as optical dividing heads. Use is frequently made of the toolroom facilities by the research division, in the manufacture of any special items such as working scale models and rigs.

To avoid delays, the main machine shop has to be able to cope with virtually any operation on components or assemblies of widely different sizes. There are the usual small machine tools, including those for thread grinding and gear generation; among the larger tools are planers, a plane grinder and vertical and horizontal borers. The vertical borer, a Schiessen machine, can accept workpieces as big as the turret of a Conquerer tank. Its horizontal counterpart, of Asquith manufacture, occupies a large portion of one bay of the shop; plenty of space is allowed round it, so that complete vehicles can be brought to it if necessary. A typical job for this machine is the final boring of the pivot bearings for the suspension arms of a tracked vehicle.

No special comment is needed on the sheet metal section other than that the personnel, because of the requisite standards of accuracy and workmanship, are more than usually skilled in their trade. Although the foundry, which casts iron and non-ferrous metals, is small, it has the necessary facilities for producing castings up to the size of the gearbox casing for a heavy tank. Thanks to the ready availability of the pattern makers' services, any special castings can be produced at short notice, and at lower cost than they could be by an outside contractor. Another small section is the heat treatment shop, which contains a variety of electric furnaces and an oil quenching bath. Again, quite large parts can be handled.

The actual erecting of prototypes is carried out in the fabricating shop, as also are any subsequent major modifications. Because of the weight and bulk of many of the components and assemblies, the shop is spanned by an overhead 70 ton travelling gantry. Another responsibility of this section is the building of any rigs required for special trials. A recent example of this type of work was a mock-up of the engine compartment of a tank; by running the engine in this mock-up, it was possible for the performance of the cooling system to be studied under controlled laboratory conditions approximating closely to those of actual service. Attached to the fabricating shop is a welding section, which is equipped to tackle all normal types of gas and electric welding of steel, including armour plate, as well as of iron and aluminium and its alloys.

In the vehicles section of the workshops are two sections,

The routine servicing of all the wheeled vehicles on trials is carried out in this well-equipped bay in the workshops. Tube lighting is installed in the pits, which form a continuous working area beneath the vehicle stations, and which contain all the necessary greasing and other equipment

one of which deals exclusively with tracked vehicles, and the other with wheeled vehicles. The work in both is of a similar nature and can be divided into three categories. In the first place, there is the routine maintenance of all vehicles on trials, for which purpose gantries, hoists and pits are installed. This activity includes the removal of the engine and transmission for complete overhaul, and the subsequent reinstallation. Since an unduly lengthy interruption of trials at the cross-country testing grounds would occur if vehicles were brought back to base for maintenance, a fully equipped mobile servicing van is kept available.

In the second category comes any stripping of the vehicle necessary for the investigation of failures that occur during the trials, together with the subsequent rebuilding after rectification. The defective parts are examined, measured and photographed as necessary by the staff of the technical section of the workshops. This office works in close liaison with the project officers concerned and, if necessary, with the research division.

The third category covers development and modification work, both on new projects and on established vehicles. As regards tracked vehicles, recent instances of this type of work are the fitting of experimenal hydraulic systems for control actuation and for cooling fan drives. Comparable activities on wheeled vehicles have included the investigation of clutch slip following an increase of engine power, the development of an inter-axle oil cooling system to reduce operating temperatures, and the cure of persistent fuel vapour lock troubles.

All the actual overhauling of engines and transmission units is done in a separate shop, as also are the rectification of failures in these assemblies and the fitting of modified or experimental components. Although much of its work is for the vehicles section, this shop is part of the production section, because it is also responsible for the building of prototype assemblies — such as gearboxes — for new projects.

It will readily be appreciated that one of the major difficulties of the officer in charge of the workshops is the planning of the work in relation to its true urgency. Naturally, each project engineer takes some convincing that his own requirements are not necessarily the most important of all. In the vehicles section, in particular, the conflicting claims of the three types of work are often difficult to reconcile.

Ionizing Radiations

A SAFETY code for workers exposed to ionizing radiations in industry is laid down in the Ionizing Radiations (Sealed Sources) Regulations, 1961, made by the Minister of Labour, Mr. John Hare, and presented to Parliament on 3rd August. Most of the requirements will come into operation in six months' time, but those requiring the notification of the use and disuse of ionizing radiations in factories are effective from Tuesday, 15th August.

Requirements are specified for safeguarding the health and safety of persons employed in factories and other places to which the Factories Acts apply, who may be exposed to ionizing radiations from sealed radioactive substances, and from certain machines, such as X-ray apparatus. They require the restriction of the exposure of workers to such radiations, the adequate shielding of sources of ionizing radiations and instructions, for workers likely to be exposed to them, about the hazards involved and the precautions to be taken. Maximum permissible doses of radiation are laid down, and the regulations include requirements for the medical supervision of workers, and for the wearing of film badges to measure personal doses received.

The regulations have been drawn up in the light of numerous observations received after the publication of two preliminary drafts and two statutory drafts, and of consultations with organizations of employers, workers and other interested parties. They were also considered by an *ad hoc* expert committee appointed to advise the Chief Inspector of Factories on the subject, by the Advisory Panel on Radiological problems in Industry and by the General Purposes Committee of the Radioactive Substances Advisory Committee. Details of the regulations are given in S.I. No. 1470, published by H.M. Stationery Office, price 9d. net.

Protection for Sheet Metal

ONE of the problems encountered in the fabrication and handling of sheet metal components is that of avoiding unsightly scratches and scuff-marks on it. In some cases, these blemishes have to be polished out; in others, of course, the flaws are concealed by the finishing processes. A self-adhesive material is now available which is claimed to give two-stage protection against scuffing during pressing operations. It is known as Sello-shield, and is manufactured by Gordon and Gotch (Sellotape) Ltd, Industrial Division, 8-10 Paul Street, London, E.C.2.

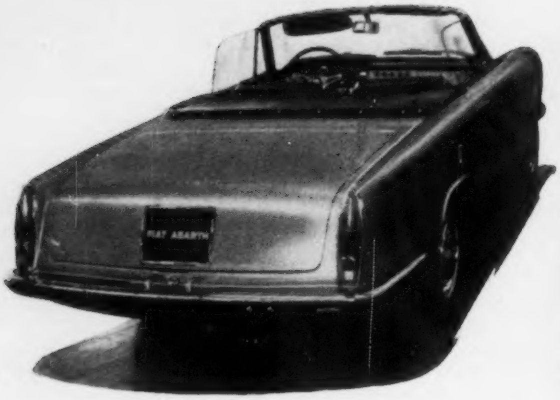
This product, which is a paper base on which is coated an elasticized adhesive, is first stuck to the metal blank. During a forming operation the paper acts as a tough, resilient layer to absorb the initial impact of the press tool; then the adhesive allows a degree of sliding movement to take place between the paper and the pressing. The paper can be either stripped off or left on the pressing, to afford further protection during handling operations. It can also be used as a base on which instructions can be written, to facilitate marking-out. This feature, clearly, can often be of advantage in sheet metal work.

This product can be either manually or semi-automatically applied, according to the size of the component. A machine has been specially designed for semi-automatic application: it presses the paper on to the surface of the metal cleanly and without creasing. This machine has an overall length of 3 ft 6 in, and a height of 3 ft. Sello-shield is supplied in rolls 100 yd long and 0·005 in thick, and is produced in widths ranging from ½ in to 48 in; its weight is 4 to 4½ oz/yd^2. The tensile strength of the material is 17 lb/in width; its elongation, on breaking, is 6 per cent, and the adhesion force is stated to be approximately 7 oz/in width.

Simple Instrumentation

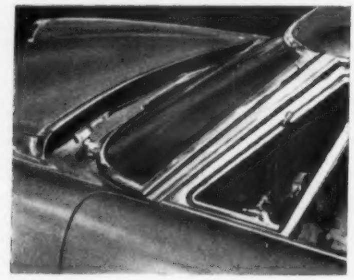
DESPITE the widespread use of instruments in modern manufacturing processes, there is still ample scope, in many industries, for more applications. A booklet on this subject, referring particularly to simplified forms of instrumentation, has been published by the Department of Scientific and Industrial Research. It is entitled "Instruments in the Factory", and is by Dr. J. Thomson, Director of the British Scientific Instrument Research Association.

In the booklet, several aspects of instrumentation procedure are discussed, and examples are given of some applications of simple instruments that can help reduce costs and increase production efficiency. Among them are: measurement of viscosity and flow of liquids, detection of smoke, and thermostatic control of water temperature. Uses of simple instrumentation in the research laboratory and fully automatic production processes are also touched on. "Instruments in the Factory" is available free from the library of D.S.I.R, at 5-11 Regent Street, London, S.W.1.



Above are the rear ends of two versions, the fixed head and drophead coupés, of the Abarth Fiat 2100. Noteworthy features of these vehicles are their plain but elegant lines. Below is a detail showing the line of the raised rear edge of the bonnet lid running into the scuttle on each side

Continental Coachwork



Part I

A Review of the Latest Trends and of Some Noteworthy Features of This Year's Models

GENERALLY, coachbuilders' exhibits show marked changes in fashion from year to year, but 1961 has seen few positively new developments. Even the Italian coachbuilders, who are renowned as leaders so far as styling is concerned, do not seem to agree in which direction to go next. Surprisingly, it appears as though the manufacturers of the quantity-produced cars will beat the specialist coachbuilders in at least one field—the wider adoption of four headlamp arrangements.

For saloon cars, rectangular shape radiator grilles are the rule, while most of the sports cars have similarly shaped grilles or air intakes but projected forwards to give an impression of eagerness to go, and appreciably lower down to enable a low bonnet profile to be obtained. Even manufacturers of bodies on the Alfa Romeo chassis are tending more and more to conform with this rectangular grille fashion, by appropriate adaptation of the traditional Alfa Romeo trefoil arrangement. Examples are the Bertone and Vignale bodies on the Alfa Romeo chassis.

So far as the sides of vehicles are concerned, the majority are devoid of excessive chromium plated adornment. Where bright strips are used it is mainly at sill level to give an illusion of length and to reduce the apparent height of the vehicle. In a few instances, a horizontal strip is used at waist level for the same purpose and sometimes to give balance to the design by breaking up the sides into harmonious proportions. It is, of course, well known that the depth dimensions of the principal areas of the sides should be either equal or multiples or fractions of one another: for example, in many instances the effective height above the waistline is equal to that below, while that below the sill might be one third of that between the sill and the waistline.

The dihedron device for breaking up areas on the sides of the bodies seems to have fallen out of favour although, because of its simplicity and effectiveness, this is probably only a temporary trend. For those who are not familiar with the term dihedron, it might perhaps be added that this, as applied to bodywork, is the forming of a distinct horizontal line at the junction between two plane or slightly curved surfaces above and below it. Several were depicted in the review of Continental coachwork published in the August 1960 issue of *Automobile Engineer*, but the sole example among the illustrations that accompany this year's article is the Abarth Fiat. The only other feature of note so far as the sides are concerned is the wide variety of door handles used: the aim, of course, is always at choosing a style of door handle to harmonize with the overall conception.

At the rear ends, there is a tendency to tidy the exhaust arrangements. In some instances, the exhaust is carried out through an aperture in the bumper, although the wisdom of this can be questioned: first, there is a tendency for bumpers to become blackened and corroded by the exhaust and, secondly, if the gases are not led away well clear of the tail end, they are liable to be drawn into the body, especially if the boot lid seal is not perfect. The reason for the latter phenomenon is that, when certain of the windows are opened, aerodynamic conditions frequently arise in which a low pressure is created in the car. This may cause air, and exhaust gases in the eddies at the rear, to be drawn in through the boot.

It is noticeable that there is still a tendency to simplify the rear lamp groupings. In some instances, this is done by tucking the reversing lamps and reflectors out of the way beneath the bumpers. This, again, is not altogether satisfactory, since they are likely to quickly become dirty in that position and, even when clean, are not so effective there. Moreover, they are likely to be damaged when the vehicle is reversed in car parks or over rough terrain.

There have been some changes in emphasis in the interiors. Last year, a high proportion of the floor coverings

were of rubber. Now, the custom built coachwork has mainly carpet on foam plastics or felt, but with small rubber mats mounted in areas subject to hard wear. Headlinings are almost all of plastics material, and a few are perforated and backed by sound absorbent material.

Dash facias are mostly trimmed with hide top and bottom, with a narrow painted metal band between. This accentuates the width and lightens the appearance. Padding is sometimes installed under the hide, to lessen the danger of injury in the event of an accident. A few facias are hide covered only at the top, and a still smaller number have the hide all over.

Door styling is now consistently good. Many coachbuilders mount the door handles in line with the armrests. Still further cleanness of design is possible where the sidelights are raised and lowered by means of electric motors. Most of the front seats are adjustable for both height and longitudinal position, while many have adjustable squabs.

Abarth

Because the bonnet profile of the Abarth body on the Fiat 2100 chassis is so low, there is an air intake scoop beneath the bumper, to supplement the rectangular grille opening. Also, in order to obtain adequate intake area, the grille is unusually wide, so the head and side lamps are vertically mounted almost the full width of the vehicle apart. The two auxiliary lamps are housed behind the grille, one on each side, and are each separated from the radiator air intake by a metal partition. The grille itself is black and is of perforated sheet, the perforations being about $\frac{7}{16}$ in deep $\times 1\frac{1}{16}$ in wide and spaced about $\frac{1}{4}$ in apart. Between each horizontal row of perforations, the metal is pressed to form a shallow channel section, extending the full width of the grille : this gives the sheet the necessary stiffness. Even having regard for the relatively large size of the perforations, it seems inevitable that the lamps behind the grille must be operating at appreciably reduced illumination efficiency.

The wing crowns are delineated by means of a line pressed along their length. On the sides, there is a line formed by means of a dihedron between the wheels. This is a continuation of the line of the wrap-round portions of the front and rear bumpers. An interesting detail is the raising of the rear edge of the bonnet lid and the matching form of the scuttle panel on each side, as shown in the accompanying illustration. The reason for raising the rear edge, of course, is to ventilate the engine compartment. At the rear, the styling is elegant. Horizontal features are accentuated by the lines of the bumper and the abrupt downward curvature of the bonnet lid. The vertical, rear lamp housings have been chosen to harmonize with the door handle and bumper forms.

An unusual feature of the interior is an adjustable footrest for the front passenger. It is a bar, of oval section having a major axis about 4 in long, which forms a relatively flat surface for the foot to rest on. This bar is mounted transversely between the forward extension of the sill and the propeller shaft tunnel. It has a spigot at each end, which fits into a chromium plated socket at the mounting points. At one end, this spigot is shouldered and spring-loaded so that the footrest can be moved axially to disengage it from its socket at the other end, and removed and fixed again in a different position by inserting the spigots in either one of the other two pairs of sockets. A noteworthy feature of both the fixed and drophead versions of this body is the plain but elegant style.

Bertone

As has already been mentioned, the Bertone Alfa Romeo 2000 is a noteworthy example of the adaptation of the traditional Alfa Romeo trefoil radiator grille to modern requirements. The central portion of the grille is retained, but the leaves on each side are represented by the ends of an

The drophead version of the Abarth Fiat 2100 is one of the few bodies in which the dihedron device is still used to form a line along the side panelling

Although there is a striking similarity between this fixed head version and the drophead Abarth Fiat 2100 illustrated above, close examination will show that there are few, if any, body panels common to both

approximately rectangular form of air intake, on which the central portion is mounted. Four lamps, two on each side, are accommodated in this air intake opening.

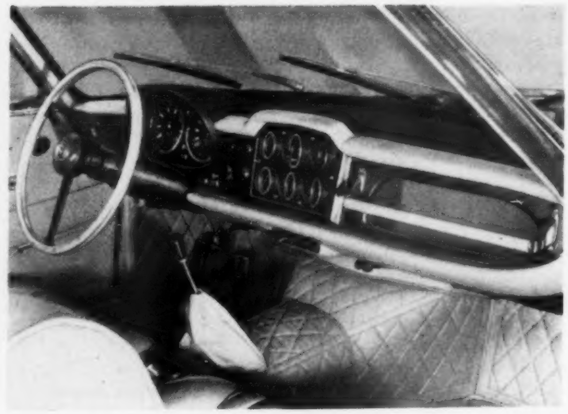
All the visible components of the grille are chromium plated steel pressings. The central portion comprises a chromium plated outer shell mounted on a V-shape, painted, pressed steel assembly, which it conceals. Between the arms of the V are six horizontal bars, also chromium plated steel pressings, each having a broad flat upper surface, the forward edge of which is turned downwards and then to the rear, to give a solid appearance as viewed from the front. The ends of the bars are tongued to register in slots in the V assembly, and these tongues are bent over, through 90 deg. A single screw and nut, in holes at the base of the V and the shell, secure the whole assembly to the lower edge of the radiator opening. The only other attachment is that of the top of the shell to the bonnet surround panel.

On each side of the shell there is a horizontal bar connecting it to the lamp assembly. This bar is a chromium plated steel pressing of similar section to that of the bars in the central portion. It is secured to the adjacent arm of the central V assembly by a horizontal screw and nut; in addition, two screws are welded beneath it so that it can be attached to the perforated backing-screen. The perforations in the screen are of elongated rectangular shape, and the horizontal spaces between them are pressed to form channel sections for stiffness.

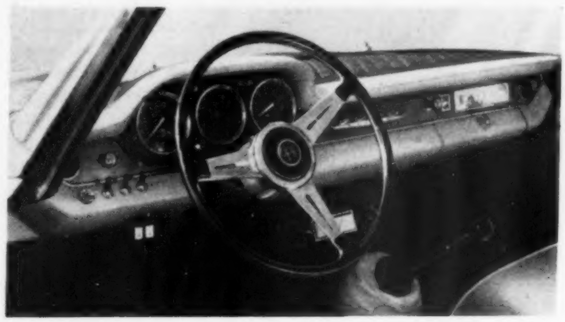
The lamp arrangement would be suitable for the new four headlamp scheme but, in fact, it comprises two headlamps and two auxiliary lamps. Their bezels are mounted on a siamesed backing plate. The direction indicators are carried in separate rectangular housings on top of the bumper.

To delineate the crowns of the front wings, a line is pressed along each from a point 4 to 5 in from the front, becoming more pronounced as it approaches the waist, where it changes its section from convex to concave and passes along the door and lower edge of the rear quarter light. On the rear wing it again becomes convex and fades out about 1½ in from the trailing edge. This progressive fading in and fading out of the line is most effective and is enhanced by the strength of the concave central portion, where the section becomes almost a 90 deg angle. As can be seen from the accompanying illustration, the form of the front and rear ends is such that the fade-out at the extremities is essential. The door handles are of the flush, pull-out type and are decorated with horizontal grooving. A recess pressed in the panel allows clearance for the fingers to be inserted behind the pull-out portion.

Inside the vehicle, a neat dash facia arrangement has been adopted. The top and bottom portions are padded and covered with hide, the upper face being also quilted. Although the quilting is attractive when the car is new, dust



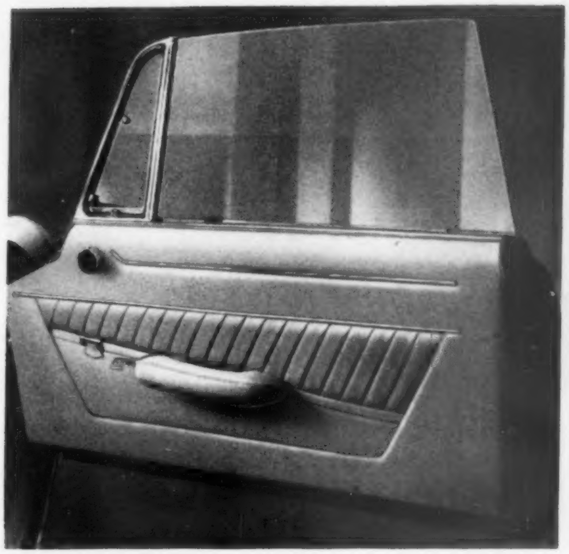
An unusual feature of the Bertone body on the Aston Martin chassis is the layout of the instruments. The six smaller ones to the right of the driver are set at an angle so that he can see them readily



The dash facia layout of the Bertone Alfa Romeo 2000 is typical of modern design, with the accent on horizontal features. At each end is a directionally adjustable nozzle for ventilation and heating

The rear end of the Bertone Alfa Romeo 2000, showing the unusually close fairing around the exhaust

Drastic modification of the Alfa Romeo trefoil grille has enabled Bertone to incorporate all the features that characterize the modern conception of front end treatment. Although the design would accommodate four headlamps, only two are used, the others being auxiliary lamps



The left-hand of these two illustrations is of the Bertone Alfa Romeo 2000 door, while the right-hand one is of the Beutler Porsche. It is of interest to observe how Bertone accentuates horizontal features and the Beutler the vertical ones, on the lower portion of the door in the right-hand illustration

would collect in the indentations and its appearance would tend to deteriorate unless it were always kept very clean.

The heater outlets on each side of the dash are louvres, adjustable so that the direction of the jet can be regulated. There are electrical controls for the door lights, and a rotating knob control for the triangular glass ventilation panel on each door. The interior door-lock handle is a lever in line with the armrest. As can be seen from the illustration, the layout of the door trim panel is exceptionally neat.

Another body that has been made by Bertone is based on the Aston Martin chassis. A noteworthy feature is the angled arrangement of the instruments. Six small instruments are mounted on a separate panel in the centre of the dash facia. As can be seen from the illustration, these instruments are set at an angle of about 30 deg in such a manner that they can be more easily seen by the driver than if they were flush fitted on the panel. They include the oil pressure gauge, clock and oil temperature gauge in the top row, and the fuel contents gauge, ammeter and water temperature gauge in the bottom row.

Beutler

This coachbuilder has, in the last few years, produced some exceptionally fine bodies on the Porsche chassis. The one that is illustrated has painted metal bumpers, with a rubber strip in a chromium plated mounting-channel extending from side to side, to take the initial impacts. Chromium plated overriders are fitted.

At the front, there is an air intake grille on each side, beneath the bumper, to direct air over the brakes. Immediately above each is another intake for the heater. Whereas the lower intakes have three horizontal chromium plated pressed steel bars, those above the bumper having a painted, perforated backing panel with a single horizontal chromium plated bar. The chromium plated spine piece, extending back along the crown of the bonnet lid, is of T-section, and thus forms a neat handle by means of which the lid can be lifted. Since the engine is at the rear, the vehicle has an exceptionally low bonnet profile.

Slender windscreen pillars, 2¼ in wide as viewed in side elevation, are a noteworthy feature : this dimension includes the glazing rubbers. The lightness of the glazing frame and roof structure is enhanced by a thin chromium plated strip surround on the windscreen glazing rubber and also by a chromium plated drip channel extending up each screen pillar, along the cantrail and down to the waistline at the rear.

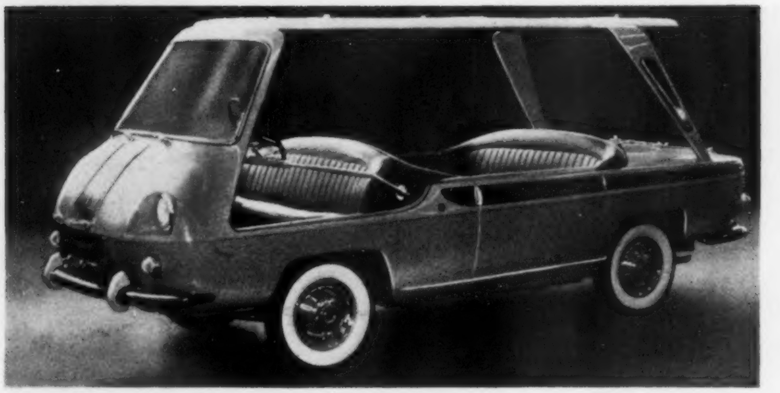
An example of meticulous attention to detail is the door sealing arrangement. The rubber portions of the seal are of J-section, the cross-piece of the J forming the flat seating on the door opening and the curved leg of the J sealing against the door. Each edge of the cross-piece is held down by a chromium plated capping strip. Below the door, along the exterior panel of the sill, is a rubber strip held down by two chromium plated strips, one along the top edge and one along the bottom edge, which accentuate the contrast between the black rubber and cream paint of the bodywork.

At the rear of the vehicle there are two grilles, each backed by a painted baffle-panel. The bumper arrangement is the same as at the front. An unusual rear lamp layout has been adopted. The main lamps are in neat groups on the trailing edges of the wings, but the reflectors are on brackets beneath the bumper. These brackets are secured to the body panel. A reversing lamp is mounted beneath the centre of the bumper, above which are two number plate illumination lamps, the latter being mounted directly on the bumper. The twin exhausts discharge through holes in the overriders, and ejector devices are fitted to them. The fundamental principles of ejectors of this kind were fully dealt with in the July 1958 issue of *Automobile Engineer*.

Noteworthy features of the interior include front seat squabs the angle of which can be adjusted, and rear seat squabs that can be folded forward, as shown in the illustration, to provide an extra luggage platform. The armrest on each door also forms part of a large pocket for maps, and the layout of the door trim panel is exceptionally well designed.

Fissore

In recent years, many beach-car designs have been produced by the Italian coachbuilders. One of the latest is the Fissore Marinella, which is based on the Fiat Multipla chassis. An unusual feature is that it has polished, solid timber bumpers of conventional shape, with chromium plated strips fitted along both their upper and lower rear edges. They are brown in colour but have white polished



Timber bumpers and overriders are employed on the Fissore Marinella. This is a sound practical arrangement for a vehicle liable to be exposed to sea atmosphere

timber overriders. At the front, there is a heater behind a small grille, and the headlamps are in rectangular recessses on each side. Conventionally mounted direction indicator lamps are installed below the headlamps.

The roof panel is about three-quarters of the width between the screen pillars and extends back from the head-rail far enough to overhang the rear decking, where it is supported by forward raked rear quarter pillars. It is covered with white leathercloth, and the interior is lined with alternate light and dark wood strips 2 in wide. On the sides of the vehicle, a chromium plated strip along the door sill of the rear compartment extends the full length between the wheel openings. At the waist, a dark polished timber insert extends from just behind the front seats to the rear, where it is swept around the back of the vehicle. Similar timber inserts are also fitted to the outer faces of the rear quarter pillars.

The top of the waistrail is capped with red leathercloth, and the same material is used for trimming the seats. Whereas the rear compartment has a door on each side, the front has only a guardrail, although the sill at that point extends almost up to waist level. The guardrail on each side is pivoted at its rear end and has a spring-loaded spigot at its front end, which registers in a socket in the front pillar. This spigot is withdrawn from the socket by pulling back the white timber handle, which, in the illustration, can be seen at the end of the guardrail.

Both the front and the rear seat frames that back on to one another are unusually light, because the top rail is common to both squabs and they are therefore mutually supporting. Rubber covering is employed for the front floor and the top of the rear sills, which are 6 in wide × 6½ in deep. The rear floor is carpeted. On the rear decking of the vehicle, chromium plated strips, with eyes for luggage straps, are fitted to the lid of the engine compartment. Long objects, such as water skis, can be carried on three transverse timber strips, also fitted with eyes for straps, on top of the roof. If heavy smaller articles were to be carried on the roof, however, they would damage the white leathercloth covering.

Ghia of Turin

An example of Continental coachwork on one of the large American cars is the Ghia, of Turin, L64 Chrysler. The front end appears to have been designed with the four headlamp arrangement in view, but only two are fitted in the model exhibited in Geneva this year, and the flashing indicators are mounted on horizontal bars, one on each side,

Above: The squabs of the front seats of the Beutler Porsche are adjustable, and those of the rear seats can be pivoted forward to form a platform for extra luggage

Left: There are four small grilles on the Beutler Porsche: those above the bumper are for the heater, while the two below are for supplying air to the brakes

On the Fissore Marinella there is a guard-rail on each side of the front seat, and there are two doors for access to the passengers' seats in the large rear compartment

The rear lamp arrangement of the Ghia L64 Chrysler is designed to harmonize with the layouts of both the front lamps and rear bumper

extending between the headlamps and the surround panel of the radiator grille. The line of the horizontal bars on each side is continued by a similar bar in the central, radiator air intake opening. All three horizontal bars are chromium plated steel pressings, and there is a chromium plated surround capping panel inside the central opening, through which the air goes to the radiator.

At the front, the wing crowns are raised a maximum of 2¼ in to look almost like vestigial fins. The distance between the crown line and the inboard edge of the raised portion is 2¾ in. Surprisingly, the rear wing crowns are not so treated. Each side of the bonnet is turned sharply down, and a clearly defined line is formed at the junction between it and the bonnet surround decking that extends out to join the raised portion of the wing crown. A spinal line is formed by pressing a channel section, about ½ in wide, along the centre of the bonnet lid.

At the rear, the lamp arrangement is designed to harmonize with that at the front. The stop and flashing indicator lamps on each side are mounted at each end of a horizontal bar, with a reflector midway between them. The tail lamps are recessed into the rear quarter panelling above. As can be seen from the illustration, the layout of the bumper has been designed to match that of the lamps: on each side, the horizontal portion and the two tubular shrouds for the irons echo the theme of the lamp arrangement above them.

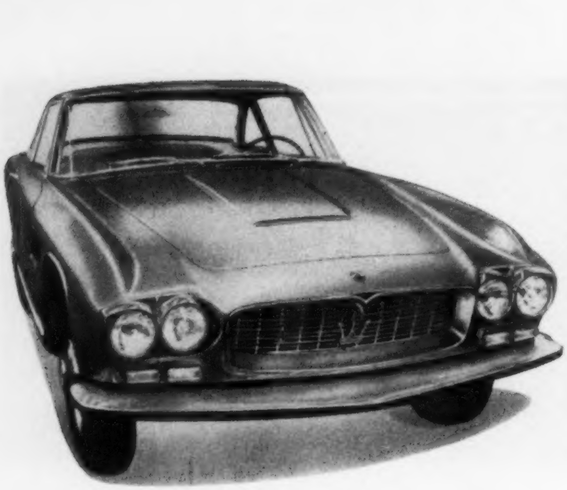
Inside the vehicle, the console and instrument panel arrangement is unusual. An accompanying illustration shows it clearly. The switches for operating the windows and heater, together with an ashtray, are mounted in the horizontal part of the console, on top of the propeller shaft tunnel. Between them and the instrument panel on the dash is the radio and speaker. An interesting feature is the Chrysler air conditioning louvres on top of the dash. These comprise rectangular frames pivoted at their rearmost edges so that their forward edges can be raised to direct the air towards the occupants. In addition, within the frames there are parallel vertical guide vanes which are linked together and pivoted about their longitudinal axes, so that they can be adjusted to deflect the incoming air sideways, according to individual requirements.

Italsuisse

At last year's Geneva show, Italsuisse produced an outstandingly well styled body on the Volkswagen chassis, and in March this year they again exhibited interesting bodies, this time on the Studebaker and 3½ litre Maserati chassis. The forward projecting four headlamp arrangement of the Studebaker is not unlike that of the Pininfarina Cadillac Starlight II, illustrated in the August 1960 issue of *Automobile Engineer*, but the grille, of course, is completely different. A high bonnet has been chosen and, between the

Right: The door handle of the Italsuisse Maserati is mounted on a chromium plated backing on the panel

Consoles have been used in several instances recently to supplement the space on the facia, for instruments and controls. In the Ghia L64 Chrysler, the dash panel and the console below are neatly blended



whereas the Studebaker has flat wing crowns, the crowns of the Maserati wings are extended upwards about $1\frac{1}{2}$ in, to form vestigial fins not unlike those of the Ghia L64 model previously described. The line of these raised wing crowns extends back to merge with the top of the door. In this instance, however, there are similar formations on the rear wings. As can be seen from the illustration, the grouping of the side lamps and flashing indicators with the headlamps on the Maserati is better than the arrangement on the Studebaker. In both models there are central dips in the upper horizontal features of the grille, to harmonize with the dip between the headlamps on each side. Other noteworthy features of the Maserati include an exceptionally light roof section and slender windscreen pillars. The elegant door handles are nicely finished by mounting them on a chromium plated backing fitted flush on the door panel illustrated on the previous page. *To be continued*

Above: A four headlamp arrangement, with paired direction indicator and parking lamps below, are features of this Italsuisse body on the Maserati chassis

Right: It is of interest to compare the front end arrangement of the Ghia L64 Chrysler with the rear end, on the previous page

Left: Another arrangement of four headlamps, but with recessed panelling between them, is that on the Italsuisse Studebaker

Below: On the Italsuisse Studebaker, the interior, pull-up handle of the door is almost concealed beneath the armrest

headlamps, the upper portion of the skirt panel is recessed to harmonize with the grille opening below. The recessed portion is bounded, above, by the overhanging front edge of the bonnet and, below, by the upper portion of the grille surround. A bumper section has been selected that harmonizes with the lines of the headlamp groups and recessed portion between them. An interesting feature of the siamesed headlamp arrangement is that the outer lamp bezel is approximately eye-shape, with its outer corner forming part of a horizontal line extending from the front to rear of the vehicle. On the Maserati, this line is simply pressed into the side panelling, but on the Studebaker it is accentuated by a chromium plated strip. On both models there is another horizontal chromium plated strip, on each side, at the level of the top of the sill and extending the full length between the wheel openings.

Another difference between the two models is that

Safety Glass for Windscreens

By R. D. LISTER,* B.Sc., A.M.I.Mech.E., A.M.I.C.E.

A Survey of the Types Available, Their Characteristics, and Accident and Injury Potentialities

GLASS has been, of course, the traditional material for vehicle windscreens and only in special circumstances has anything else been used. One of the characteristics of glass, that of forming a cutting edge when broken, has given rise to the requirement for the glass used in vehicle windscreens to be safety glass. In Great Britain, the Traffic Act of 1930 made it compulsory for glass used in vehicle windscreens to be safety glass; the latest regulations specify safety glass for use in windscreens and all windows on the outside of passenger vehicles. For goods vehicles, windscreens and windows in front of and on each side of the driver's seat must be of safety glass, as also must forward facing windows of public service vehicles.

Safety glass, as defined by B.S.857:1954,[1] is "a glass which, after fracture, gives fragments which are less liable to cause severe cuts than those of ordinary glass." The same specification recognises two types of glass, heat-treated—more commonly called toughened—and laminated glass, as complying with these requirements.

Type of safety glass used for windscreens

Laminated glass. This type consists of two sheets of glass with a relatively thin transparent layer interposed between them. When laminated glass was first manufactured, this inter-layer was celluloid, but later a cellulose acetate was employed; but for some years now a synthetic material, polyvinyl butyral, has been used. The sheets of glass retain the characteristics of untreated sheet, or plate glass; and, for windscreens, the nominal total thickness is usually $\frac{1}{4}$ in. On impact, such as a blow from the head, laminated glass breaks up into a star-shaped pattern of glass splinters, which are held together by the inter-layer.

When a sample is broken under static pressure applied by a dome shape object, resembling a human head, fracture occurs as a result of the bending stresses. First the outer sheet of glass fractures radially from the point of contact with the dome. Continued loading of the dome produces further bending and, finally, the inside sheet cracks in a similar way. At this stage the inter-layer is not penetrated. Only after continued loading does the fractured glass bulge outwards and circumferential cracks or fractures take place around the point of impact. It is usually at this stage that tearing of the inter-layer takes place and permits complete penetration. This type of glass fracture can frequently be seen in vehicles with a laminated screen which have been involved in accidents. Illustrated in Fig. 1 is a laboratory fracture of laminated glass by a dome shape object, and Fig. 2 shows the fracture pattern produced when the glass is struck by a head during an accident; the patterns of fracture are similar.

Toughened glass. Windscreens of this type are usually made from plate glass and consist of single sheets which, in the final stages of their manufacture, have been heat treated so that compressive stresses are induced and remain in the surfaces of each face of the glass. By virtue of its prestressing, this type has a high resistance to bending. Normally, the internal stresses are in equilibrium, but in the event of the glass being broken by excessive bending or if the outer skin is damaged by a sharp object such as a hard angular

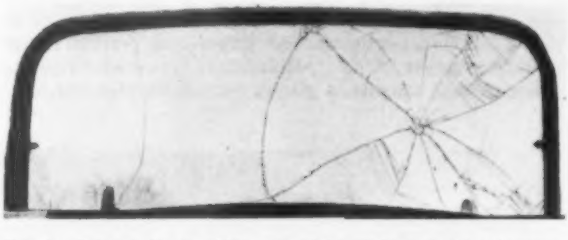


Fig. 1. Fracture by a rubber covered hemisphere in the laboratory

shaped stone, the entire screen fractures immediately. Toughened glass cannot, therefore, be modified in shape after the final toughening process. The sizes of the fragments of glass particles vary, being smallest when the greatest amount of prestressing has been produced in the glass.

The size of the particles is a convenient method of indicating the degree of toughening given to the glass and, in the case of the present British Standard, a minimum particle count of 60/4 in^2 of glass is specified, but under the latest amendment, a windscreen having a zone in front of the driver which gives a particle count of between 80 and 160/16 in^2 is also permitted. As is well known, the particle size also determines the degree of visibility through a shattered screen. It also determines to some extent the character of the edges of the glass. In Great Britain, toughened glass windscreens are usually made from $\frac{1}{4}$ in plate glass, though $\frac{3}{16}$ in plate is also used in some cases.

Characteristics of both types of windscreen

The forces that will fracture windscreens depend upon the size, shape, thickness and type of safety glass used. From a few laboratory measurements, it was found that the static force needed to fracture the windscreen of a typical British car having laminated glass of $\frac{1}{4}$ in thickness was about 150 lb, when the load was applied at right angles to the glass at a point directly in front of either the passenger or driver. On the other hand, owing to the prestressing of toughened glass, the forces needed to shatter this type of windscreen are considerably higher. Laboratory tests made on a number of different, $\frac{1}{4}$ in thick windscreens, curved and flat, indicated forces required to shatter ranging from 910 lb to 2,050 lb. The forces were applied, by means of a rubber-covered hemisphere, at right angles to the face of the glass, mid-way between the top and bottom and one-third of the way along from one end. The area of contact between this hemisphere and the glass was 2 in^2 when the applied force was 200 lb, and $5\frac{1}{2}$ in^2 when the force was 1,000 lb. This compares with an average figure of 2·4 in^2—ranging from 1·3 in^2 to 3·6 in^2—for the area of contact obtained for 12 people whose foreheads were pressed onto a glass surface.

Types of edges on fragments or particles

Examination of the edges of particles from both types of glass shows that there are appreciable differences. The edges of the laminated glass show, as would be expected, the same characteristics as those of normal plate glass from

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which it is made. When it is broken by bending stresses, a cup and cone type of fracture is obtained, which produces edges with razor sharpness. These razor-like edges frequently extend over long lengths—in some instances several inches—of the fragments, but the corresponding matching edges from which they were broken are rounded. Spear-like fragments may also be formed.

Toughened-glass particles, on the other hand, which are produced when the entire screen shatters because of the change in the internal stress equilibrium, do not have these razor-sharp edges but have fracture planes which are nearly at right angles to the faces of the glass. On many of the edges of these particles, however, a small triangular piece at the junction breaks away and leaves that portion of the particle rounded. The types of edges described for plate, laminated and toughened glass are shown in Figs. 3 and 4.

produced having varying degrees of heat treatment and these gave a variety of patterns after fracture, as shown in Figs. 5 and 6. Toughened windscreens having these types of fracture patterns would of course solve the visibility problem, and they are in use on the Continent today; but, unfortunately, they introduce other undesirable features. Tests made with a car fitted with the disc-tempered type of windscreen, Fig. 5a, showed, in the case of a flat screen, that if the screen is shattered while the vehicle is travelling at a speed greater than about 55 m.p.h, the particles, and the complete disc with jagged edges and some particles still firmly attached to it, could blow in from the screen and possibly strike the steering wheel rim, and be deflected towards the driver's face.

The danger arising from the type of screen having a barrier zone dividing the screen in front of the driver, was that, in

Fig. 2. Two views of a laminated screen fractured as a result of being struck by a passenger's head in a car involved in an accident on the road

It can be seen that the included angle of the razor-sharp edge is about 10 deg.

When, however, glass is only lightly toughened, in an attempt to produce large particles, the fracture pattern occasionally contains some long splines of glass whose edges begin to approach razor sharpness. In Fig. 4b is a section of a spline of this type, in which the included angle of the edge was about 35 deg. The problem, then, is to avoid toughening in this range and yet, at the same time, to perform the operation in a manner such that large particles are formed on fracture of the glass.

It is clear that the safety features of these two types of glass are obtained in completely different ways: with laminated glass the aim is at keeping the fractured pieces together so that their edges are not exposed; whereas with toughened glass it is at ensuring that the edges of the particles are not capable of causing cuts.

Vision through special types of windscreen

A further requirement in some specifications is that, in the case of the windscreen, there shall still be sufficient visibility after fracture to enable the driver to bring the vehicle to a stop; in the British Standard this is merely implied by reference to the particle count for toughened glass. Visibility through a laminated screen is not greatly impaired by fracture, even if it should occur immediately in front of the driver, for he can easily see round it by moving his head slightly. However, in the case of a shattered toughened screen, particularly when the particle count is high and therefore the individual particles are small, considerable loss of visibility can occur.

In an attempt to overcome this problem, windscreens were

the event of an accident, only one portion of the screen might shatter and leave the remainder with a rigid, jagged raw edge of glass held firmly in position, Fig. 6. Occupants of the car might then be thrown against this edge.

Visibility could be made satisfactory merely by arranging for fracture into a few very large particles, though not as large as the single disc, in front of the driver only. Development along these lines has taken place and toughened windscreens of this type are now being used. One specification used in Germany calls for a particle count, after fracture, in an area in front of the driver, of the equivalent of neither less than 12 nor more than 20 particles/in^2. A windscreen having a fracture pattern with somewhat bigger particles than this in front of the driver, and which thereby provides better visibility after fracture, is illustrated in Fig. 7. It remains to be seen whether the particles can be kept large enough to provide adequate vision without introducing any other difficulties.

An interesting type of fracture, which does not seem to have been developed, is one having the appearance of a series of honeycombs or small discs[2], Fig. 8. The Road Research Laboratory has shown that for forward visibility the most important part of the screen is that in line with the driver's eye and the horizon so that a relatively small number of these discs suitably positioned in the screen would be expected to provide good vision after fracture.

Factors affecting visibility after fracture

A number of factors can influence the visibility through toughened glass after fracture. In comparing vision through screens having different fracture patterns, use is sometimes made of photographs taken from the driver's eye position

looking through the screen. However, photographs do not reproduce the impression that a driver gets or exactly what he sees. A normal driver sees with binocular vision, whilst the camera view is monocular; also, he sees objects over a very much wider tonal gradation than can be reproduced photographically, either by transparencies or prints. He also can and does search, by means of eye and head movement, to find the best viewing position.

The assessments of vision given in this article were made, therefore, both objectively and subjectively by a number of observers making independent assessments. Tests were made with specimens of toughened glass having nominal particle counts of 40, 20 and 10/in² to obtain some numerical comparison of these three types. They showed the effect of the particle count, the slope of the windscreen and the degree of contrast of the target being viewed, on the facility number of fragments/in² was approximately 40, 20 or 10. The targets were moved slowly towards the observer, who kept his head still, and the distance at which the numerals could be read correctly was noted. The averages of the results obtained by seven observers, for the targets having different contrasts, are given in Fig. 9.

There were considerable differences in the distances noted for the different observers but the relative distances for the three targets for a given observer were approximately those shown: for this reason the scale of distance is given in arbitrary units. With the target having the lowest contrast, the distances were short and it will be seen that the numerals on the target could be identified at somewhat greater distances through the 10 particle count than through the 20 particle count glass. For the target having medium contrast, there was little difference in the distances at which the numerals could be identified through the 20 or 10 particle count glasses. These distances, however, were approaching those at which the angles subtended at the eye by individual fragments, and by the test numerals, were about the same. For the high-contrast target, the observer was usually able to read the numerals through many individual fragments.

Fig. 3, below. Razor-like edge on fractured plate glass compared with a spear-like fragment from a sheet of laminated glass

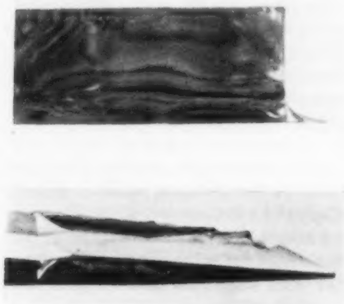

Fig. 4a. This illustration, above, shows a particle of fractured toughened glass. The edges exhibit fracture planes which are nearly at right angles to the faces of the glass and the junctions are rounded where the fine sharp edges break away

Fig. 4b. Cross section of a long spline typical of those that are produced when only lightly toughened glass is fractured

with which drivers are able to recognize objects and shapes.

Some of these tests were made using sets of 3½ in × 3½ in numerals prepared photographically to give different contrasts between them and their background. Several observers in turn viewed these numerals through the different shattered-glass specimens at places on the glasses where the

Table I—CHIP MARKS ON WINDSCREENS OF VARIOUS CARS

Vehicle	*Year*	*Mileage, 1,000's*	*Angle of windscreen, deg**	*Eye distance from windscreen, in*		*Height of windscreen from ground, in*		*Number of chips on windscreen*
				Min.	*Max.*	*Min.*	*Max.*	
Volkswagen	1956	49	59	15	22	42	53	3†
Ford Anglia	1960	2	55	19	24	40	54	1
Austin ADO15	1960	3	53	23	29	36	48	6
Hillman California	1955	64	53	15	18	41	54	77
Ford Zephyr	1954	30	50	14	21	41	54	46
Vauxhall Velox	1955	39	48	18	23	47	61	11
Renault Dauphine	1960	11	47	16	23	40	51	14
Morris Oxford	1959	45	47	22	27	44	57	35
Austin A40	1960	10	47	20	25	38	53	3
Triumph Herald	1960	7	46	18	26	37	49	5
Wolseley 6/90	1957	41	46	16	20	43	54	20
Citroën Safari	1960	5	45	21	25	44	57	0
Morris Commercial 2 ton	1959	27	73	17	29	49	73	20
Morris Commercial 2 ton	1959	48	70	16	37	52	84	21
A.E.C. Mercury 4 ton	1956	34	74	21	29	70	94	8
Ford Thames tipper 2 ton	1953	31	76	17	22	62	78	94
Ford Tracker tipper	1959	10	81	24	28	66	84	1
Bedford tipper 2 ton	1957	19	65	22	27	61	77	0

**Angle of windscreen to horizontal at centre of windscreen. †Second windscreen—first one shattered at mileage of 41,600*

Some indication of the importance of the slope of the windscreen, the particle count, and the glass thickness can be obtained by considering ideal fracture patterns in which all the particles are square fragments of glass: thus in a fracture of 20 particles/in², all particles are considered to be fragments of glass 0·223 in square and so on. The obstruction to vision caused by the plane of the glass thickness is shown in Fig. 10, from which it would appear that, in this ideal form, reducing the thickness of the glass from $\frac{1}{4}$ in to $\frac{3}{16}$ in has approximately the same effect on vision as halving the particle count. Small changes in the slope of the windscreen have bigger effects at the greatest windscreen slopes. Details of the slopes of the windscreens of some vehicles are given in Table I. This ideal consideration does not, of course, take into account the effect of the glare produced from the fracture planes with the subsequent degradation of the image, nor the variations in the sizes of particles that normally occur in any fracture pattern.

Some further tests were carried out to assess the relative merits of different particle counts by making runs on an aerodrome with a car fitted with different screens. Specimens of toughened glass were mounted just in front of the normal windscreen and were fractured while the car was being driven at speeds of about 50 m.p.h. The angle of the windscreen to the horizontal was 57 deg. On the track, some 25 cardboard obstacles about 3 ft high and 2 ft diameter had been placed at irregular intervals so that the driver had to steer to avoid them. Runs were made both with the sun behind and facing the observers in the car. As a result of these tests, it was found that with the nominal 20 particle count glass, although the view ahead was momentarily lost at the instant of shattering, it was possible to avoid the obstacles and to steer round them at a speed of about 45 m.p.h. But it was noticed that, when driving round the perimeter track, some difficulty was experienced because of the reduced contrast around the verge. With the glass of nominal 10 particle count there was a considerable improvement, and although the visibility was, again, reduced at the instant of shattering, the focus of attention on the obstacles ahead was not lost. Even under adverse lighting conditions it was possible to negotiate the obstacles at speeds of at least 60 m.p.h.

Similar qualitative results were obtained in more recent tests with a car fitted with screens in which there was a zone, in front of the driver, which after shattering, gave larger particles than in the rest of the screen. In these tests the driver was not aware of the precise point at which the shattering would occur. There was considerable variability in the vision through these windscreens, but in most cases drivers were able to continue driving at speeds up to at least 60 m.p.h. Some difficulty was experienced on bends but this could be overcome by the driver's moving his head nearer to the windscreen. The particle count in this zone in front of the driver was between 5 and 10 particles/in² but, because this count was taken over an area of 16 in², some of the individual particles were larger than the count suggests. Usually, one or more particles of irregular shape but about 1 in² in area, were present in the zone after fracture.

Reference has been made to the ability to see sufficiently well through fractured toughened-glass screens, of the coarser particle counts, to be able to drive at speeds of 60 m.p.h. or so. If the speeds are much higher, 70 m.p.h. or more, it is probable that the screen would blow in, so the requirement to see through the fractured screen would not arise. In laboratory tests, a flat windscreen blew in at about 55 to 60 m.p.h, while in a number of tests on one particular car, a curved screen blew in if it was shattered while travelling at 65 m.p.h. or more.

Liability to shattering and accidents

As has already been mentioned, toughened-glass windscreens may shatter when the stress equilibrium is sufficiently disturbed. This can happen when the screen is struck by a stone or when the vehicle is involved in a collision. It has also been reported that fractures have occurred as a result of fretting caused by irregularities in the mounting, either in the frame or when directly mounted in the body.

In addition, a number of cases are reported where the windscreen shattered for no obvious reason, such as when the vehicle was in the garage or when there was no possible chance of a stone's being thrown up, and examination of the fracture pattern revealed that the fracture did not originate from the edge. Two possible explanations for some of these fractures are often advanced. It has been suggested that failure could originate from a minor defect in the glass which was not sufficient either to be detected or to cause failure during production. Furthermore, glass exhibits a decrease in its breaking strength when the load is applied for a long time: it is generally believed this is because of microscopic cracks or checks, in the surface, causing a stress concentration from which fracture in the glass is propagated. These cracks spread under stress and cause failure when the glass is sufficiently weakened. Some support for this explanation was obtained by loading a number of curved, toughened windscreens by means of a rubber-covered hemisphere. The load applied was such that it did not cause immediate

Fig. 5a. The fracture patterns of a toughened glass windscreen specially heat-treated so that adequate visibility is retained after breakage

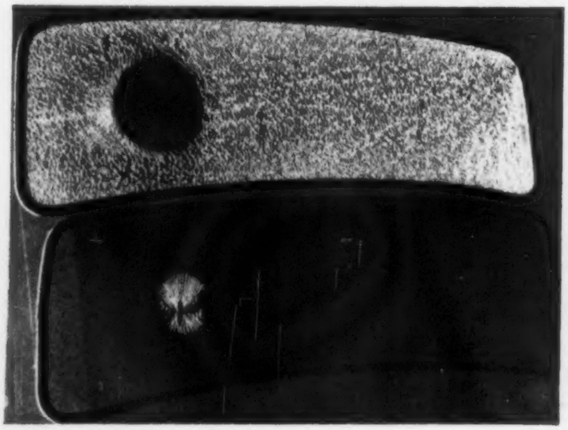

Fig. 5b. Strain pattern, as viewed through a polaroid filter, of the type of toughened glass windscreen of Fig. 5a before it was fractured

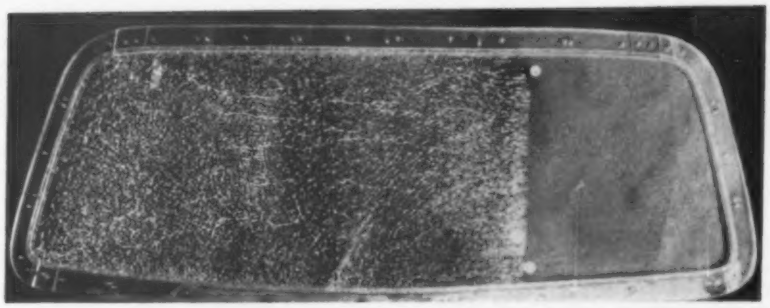

Fig. 6. With this type of screen, in which the glass is toughened in such a manner that one large portion remains clear in the event of damage involving fracture to the other, there is a danger that the occupants of the car might be thrown against the jagged edge of the undamaged portion

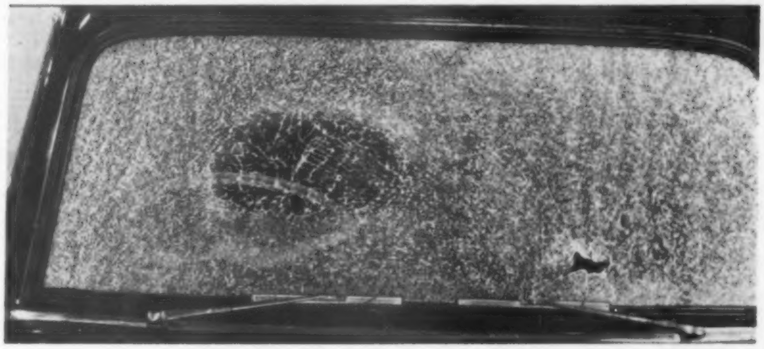

Fig. 7. This illustration shows a fractured windscreen that has been toughened in such a way that the particles in the area immediately in front of the driver are larger than the remainder so that there is relatively little impairment of visibility. It remains to be seen whether the particles in this area can be kept large enough to provide adequate vision without introducing any other difficulties, such as formation of splines that have extremely sharp edges

failure. After leaving the windscreen in the loaded state for some time, in some cases many hours, the screen under test shattered. Various levels of loading were tried and the time that elapsed before failure occurred was noted in each case.

Evidence that screens are frequently struck by stones can readily be obtained by carefully examining windscreens and noting all the chip marks in the surface of the glass. A count of chip marks on the windscreen, for a number of vehicles, is given in Table I. It shows that windscreens may be struck many times before shattering occurs, and that even commercial vehicles whose windscreens are relatively high above the ground are liable to be struck by stones.

Stones taken from a particular stretch of the London to Portsmouth road were projected by a catapult at sample windscreens, at speeds varying from 25 to 50 m.p.h. As would be expected, the angular type of stone appeared to shatter the screen more readily than the rounded type. In some cases when rounded stones were projected, the stone itself was broken without shattering the screen. Rounded stones, however, are not the most suitable for road surfacing materials. Those used all weighed between 4·5 and 5·0 gm; the velocity before impact was obtained by means of a high-speed camera. Stretches of road that have been notorious in connection with shattered windscreens are usually those where the traffic is relatively dense and speeds fairly high, for example, the London to Portsmouth road. It is also possible, however, for windscreens to be shattered by stones at lower speeds. An increase in the frequency of windscreen shattering has also been reported on roads where surface dressing has been newly carried out. On one short stretch of road, where surface dressing was being carried out but had been interrupted by rain, nine cases were reported in one afternoon. Particular care should, therefore, be taken when driving on roads that have been newly surface dressed.

There is no doubt that the sudden shattering of a toughened-glass windscreen can be very alarming to the driver. However, it is important to know whether accidents are caused as a result. Evidence on this point is not easy to obtain, but one particular police division showed that, over a number of years, reports of 245 toughened-glass windscreens having been shattered had been received. A further eight side windows were also reported as having been shattered. Of these incidents, 115 were said to have occurred when there was no other vehicle near at the time, and only one accident was reported as being caused—the windscreen of a lorry shattered, the driver braked, and a motorcycle ran into the rear of the lorry.

In the first year of operation of the London–Birmingham motorway, 60 cases of toughened-glass windscreens shattering were known to the police. Of these incidents, two resulted in damage-only types of accident; in one case, the driver braked and a following car ran into the rear; and in the other, the driver swerved, striking the offside corner of a lorry. Detailed investigation of accidents by the Road Research Laboratory showed that out of 546 accidents on different roads, in which 775 vehicles—cars and commercial vehicles—were involved, 112 toughened and 56 laminated windscreens were shattered or fractured as a result of the accident; but none of the accidents was caused by windscreen fracture.

Table II—NUMBER OF OCCUPANTS WHOSE HEADS WERE INJURED IN CONTACT WITH WINDSCREENS, ACCORDING TO WINDSCREEN TYPE AND SEVERITY OF INJURY

Condition	*Severity of head injury*	*Type of glass*		*Type of glass not known*
		Laminated	*Toughened*	
Broken	Slight	14	8	0
	Serious	4	2	0
	Fatal	0	0	0
Not broken	Slight	0	2	2
	Serious	0	0	0
	Fatal	0	0	0
Total		18	12	2

Ratio of injuries, laminated:toughened glass = 18:12 = A
Ratio of windscreen types in use, laminated:toughened glass = 33:266 = B
Ratio of injuries, laminated:toughened glass, weighted for Nos. in use = A:B = 12:1

From reports of windscreens shattering it has been estimated that, on roads other than motorways, one windscreen shatters per half a million vehicle-miles travelled. This is obviously a very general figure and wide variations would be expected, because much would depend on the road surface and the density of the traffic. On the motorway, the estimated vehicle mileage during the first year was 346 million. After making allowance for the proportion of vehicles having laminated windscreens, a figure of about 5 million vehicle-miles per shattered windscreen is obtained. Other data from large transport organizations gave figures of one windscreen shattering per 300,000 to 400,000 miles. Thus, although troublesome when it occurs, on a mileage basis, it is not frequently experienced nor is it a serious cause of accidents.

Injuries and the windscreen

An analysis of coroners' reports for 1953–1955, relating to the death of vehicle occupants, showed that between 65 and 75 per cent of injuries causing or capable of causing death were to the head and neck.[4] In another investigation of accidents involving injury, it was found that three-quarters of the injuries to the head were due to its striking the windscreen or projections near the windscreen.

No experimental method has yet been devised which satisfactorily evaluates the injury-producing potential of glass fragments. However, since both laminated and toughened windscreens are used in this country it is possible to compare the injuries produced in road accidents when the windscreen is involved. In an accident, the occupants may be flung violently about inside the vehicle, and it is often very difficult to say with certainty which particular part of the vehicle contributed to any specific injury. However, from the accident investigations carried out by the Laboratory, it was possible to establish the cause of injury of 95 persons who received head injuries. Of the total, 32 hit their heads on the windscreen, 12 on the windscreen frame, 19 on the interior mirror, 13 on the sun visor and five on the roof. Twelve persons received head injury from contact with other projections above the windscreen. Table II shows the type of windscreen involved and the severity of injury of the 32 occupants who received head injuries by striking only the windscreen.

It will be seen that there are more cases of head injuries involving laminated glass than toughened glass windscreens, and since the ratio of vehicles fitted with laminated windscreens to those fitted with toughened windscreens, based on a count of vehicles in use, is about 1 : 8; this indicates that laminated windscreens are more likely than toughened ones to cause serious injuries to the occupants of the vehicles.

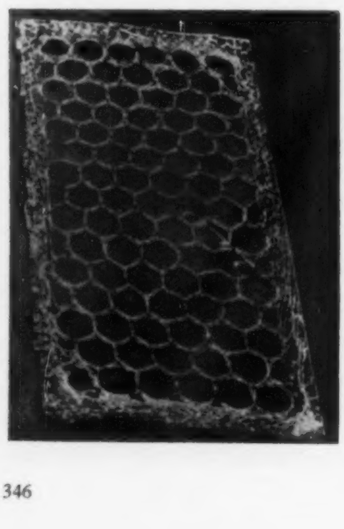

Fig. 8. Multi-disc or honeycomb type of fracture of an experimental sheet of toughened glass[2]

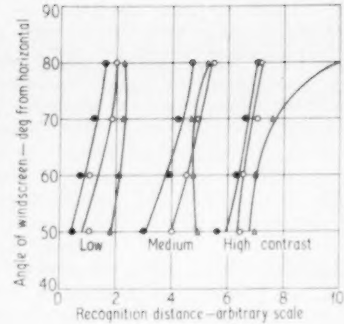

Fig. 9. Recognition distances of targets, having different contrasts, when viewed through shattered toughened glass. The results are the mean of all those obtained from tests of seven observers

● 40 particle count
○ 20 particle count
△ 10 particle count

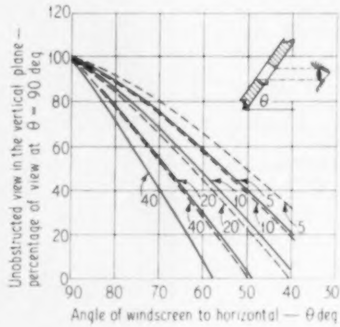

Fig. 10. Effect, on visibility, of windscreen slope, particle count and glass thickness, with ideal fracture patterns in which all the glass particles are square fragments

—— particle count $\frac{1}{4}$ in glass
- - - - particle count $\frac{3}{16}$ in glass

In America, direct comparisons of the injuries due to the two types of windscreen glasses is not possible, since only the laminated type is permitted to be used. However, some investigations into injuries due to side windows have been made by the Cornell University Medical College.[5] These showed that of the 1,672 occupants of cars involved, only 27 of them sustained injuries from the side window glass. Of these, 20 minor and six moderate injuries occurred with laminated glass and only one minor with toughened glass. It was estimated that about 30 per cent of the cars had toughened side windows. This makes the ratio of injuries for laminated:toughened side windows 9:1, when weighted for numbers of the two types of glass in use.

At a conference[6] "Windscreens and Traffic Safety" held in Germany in 1959, Dr. Friedhoff of the Surgical University Clinic at Cologne, reported that in a study of 500 accidents the type of glass involved could be determined in 517 vehicles: 79 per cent had toughened glass and 21 per cent laminated. The proportions of persons injured by the windscreen as a percentage of the total number injured were 18 for toughened and 22 for laminated. Thus the ratio of injuries, laminated:toughened weighted for the numbers in use is $4\frac{1}{2}$:1.

Possibilities of skull fractures and concussion

In view of the much greater forces needed to break toughened windscreens than laminated ones, the fear is often expressed that skull fracture and concussion may be more prevalent with toughened windscreens. As a result of measurements using model skulls, it was concluded by Sellier[7] that, below the point at which shattering or fracture of the windscreen occurs, the duration of impact with laminated glass is considerably shorter than with toughened. He claimed that this gives rise, in the case of laminated glass, to pressure waves through the skull, with the greater probability of causing concussion damage.

Laboratory tests on plastics skulls, simulating human skulls, have also been carried out in America by Ryan,[8] who reported that the plastics skulls all fractured when impacting toughened glass at speeds exceeding 17 m.p.h;

maximum decelerations of about 300 g were noted. No fracture occurred on laminated glass, except when the interlayer thickness was increased and the temperature was reduced to 0 deg F.

From accident data, however, it appears that serious concussion does not arise as a result of impacting the windscreen only, and skull fracture is entirely absent. Loew[6] gives details of 51 cases of injury involving impact with the windscreen only. In 12 cases no brain injury was involved, and in 37 cases there was brain damage of the first degree in only two cases was there brain damage of the second degree; serious brain damage and open brain injuries were entirely absent. Owing to lack of data a comparison of injuries based on the types of glass could not be made. The Road Research Laboratory accident investigation showed many cases in which a toughened windscreen was shattered by a person's head without any injury to the head. Work carried out by the Road Research Laboratory on motorcyclists' safety helmets also suggests that no permanent injury is likely to occur to the head if the impact time lasts less than 1/200 second, the maximum deceleration is less than 500 g, and the maximum rate of increase of deceleration is less than 200,000 g/sec.

That Ryan's laboratory tests do not agree with what has been found on the road may have been because there was no simulation of the skin tissue between the human skull and the glass, and because the weight of the model skull made no allowance for the stiffness of the neck and other factors contributing to the effective mass of the skull. Having regard therefore to the evidence of injuries, including skull fracture and concussion, there is a strong case to be made for use of toughened in preference to laminated glass windscreens.

Two points should be mentioned, however: if safety harnesses were to come into universal use, the risk of injuries due to cutting by the windscreen would be of less importance, and the use of laminated glass would be favoured; also, in very cold countries, a shattered toughened screen might expose the occupants to the risk of death from exposure, and the risk from cuts becomes of secondary importance; thus, in these circumstances, laminated glass might be preferable.

The work described in this article was carried out as part of the programme of the Road Research Board of the Department of Scientific and Industrial Research, and it is published by permission of the Director of Road Research.

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Hot Galvanizing

IN VIEW of the interest now being shown in galvanized sheet steel for the under portions of body structures, a new booklet issued by the Hot Dip Galvanizers Association, of 34 Berkeley Square, London W.1, will be of use to automobile engineers. It is entitled "Hot Galvanizing—The Process and Product", and it is the second in a new serie of technical booklets to be issued by the Association. The hot galvanizing process is described and the booklet contains notes on the formation of alloy layers, spangle, corrosion resistance, fabrication and methods of finishing.

S. M. M. and T. Standards

SOME amendments to the handbook "Standards of the British Automobile Industry" were issued in July. They include a revised index and alterations to the following sections: non-metallic materials, tyres and wheels, electrical equipment, trailers, and engine and chassis. Copies are obtainable from the Society of Motor Manufacturers and Traders Ltd, Forbes House, Halkin St, London S.W.1.

Polyester Handbook

THE FIFTH edition of the "Polyester Handbook" was exhibited at the International Plastics Exhibition at Olympia, London, in July. Although this edition bears some resemblance to its predecessors, it has been extensively revised and re-written. The chapter headings are as follows: Introduction and general characteristics; Chemistry; Curing and general formulations; Reinforcements; Scott Bader polyester products; Ancillary products; Mould release agents; Gel coats; Methods of fabrication; Applications; Design considerations; Quality control; Visible flaws and common defects; Machining, finishing and repair; Properties; and Postscript. This 130 page book is obtainable from Scott Bader Ltd, of Wollaston, Wellingborough, Northamptonshire.

Rear Lamps

A NEW approach in the design of rear lamps was exemplified at the 1961 International Plastics Exhibition in London. In this design, the aim has been at obviating the difficulties associated with combined metal and plastics assemblies. The complete rear lamp cluster shown in the illustration was exhibited by Duplex S.A, of 124 Rue Lafayette, Paris, 10e.

It comprises four main parts. One is the complete surround of moulded polystyrene, plated on the inner surface to provide a chromium finish and at the same time to give depth, so far as appearance is concerned. There is also a red upper and an amber lower moulded polystyrene lens. The back-plate, which is not shown in the illustration, is supplied complete with three bulb holders and is of moulded transparent polystyrene.

The complete assembly has good electrical insulation properties and is non-corrosive. By virtue of its layout, protection is afforded against the entry of dirt and water, which could cause short circuits. All the four parts of the lamp clip together and are secured, to the rear of the steel wing pressing, with fastenings accessible for replacement of the bulbs with the minimum of trouble. These lamps are fitted to the latest Peugeot cars, and are produced on Smal Plastique screw type injection moulding machines.

The all-plastics rear lamp assembly that was exhibited at Interplas

BOOKS

Brief Comments on recent Foreign Publications on Automobile Engineering

Untersuchungen über den Kohlenoxydegehalt der Luft in Kraftfahrzeugen (*Investigations Regarding the Carbon Monoxide Content in the Air Inside Motor Vehicles*). Deutsche Kraftfahrtforschung und Strassenverkehrstechnik. No. 142.

In German, by R. Barth, Dr. Ing.

Düsseldorf: VDI-VERLAG G.m.b.H. 1960. $11\frac{3}{4} \times 8\frac{3}{4}$. 12 pp. Price DM.11.30.

The possibility of carbon-monoxide from the exhaust gases adversely affecting occupants of cars must be considered carefully, especially with cars having heaters comprising exhaust gas heat exchangers or in which some of the engine cooling air, in the case of air cooled engines, is diverted to the interior. In the latter case, especially with rear mounted engines, it might be possible for some of the exhaust gas to be mixed with the entrained cooling air and thus find its way into the vehicle body.

To ascertain the amount of carbon monoxide inside the vehicles, samples of air were drawn from a number of production cars operated under controlled conditions. Particular attention was paid to the possible influence of the layouts of the exhaust and heater systems, and the effect of leaks, speed and load, the ambient conditions and the air flow around the vehicles. The report mentions briefly the reasons for these investigations, the effect of carbon monoxide on passengers, the test procedure and equipment used, result evaluation and finally the results themselves. Of particular interest is the effect of the exhaust location in rear engined vehicles on the amount of CO entering the vehicle through the heating system. This is a useful investigation ably presented and certainly encouraging so far as the results are concerned.

Kraftstoff-Motor-Kennungswandler (*Fuel-Engine-Transmission*). VDI Report, No. 42.

In German.

Düsseldorf: VDI-VERLAG G.m.b.H. 1960. $11\frac{3}{4} \times 8\frac{1}{4}$. 94 pp. Price DM.27.

In the volume under review there are nine papers presented at the October 1959 convention of the automobile section, ATG, of the German society of engineers, VDI. The first paper by the then President of the S.A.E., Leonard Raymond, deals with the development challenges to research work in the U.S. automobile and fuel industries. In this masterly and stimulating survey the author has succeeded in encompassing within ten pages a wealth of information, and has presented it in a manner which is bound to foster further interest and action, with particular reference to the challenges so clearly and lucidly pointed out by Mr. Raymond. The subjects dealt with are engines, transmissions, including final drives. Also, the interdependence of engineers and fuel technologists and of designers and research workers is shown up as a most important factor, which must be appreciated and encouraged if the development is to proceed along effective lines.

Next is a paper by Raymond Marchal, Ingénieur Général de l'Air, who considers the possibility of the use of atomic energy for vehicle propulsion. The author is hampered by the necessity of dealing with this new and complex subject within a compass of twelve pages, and also by the obvious necessity of adhering to the stringent security regulations. As a result, the matter is considered on rather general lines, although some data relating to well-known U.S. naval applications are also given. As is mostly the case with papers relating to this subject, the safest policy is to talk mainly about what others are doing, thus avoiding the risk of upsetting the security services, whose problems in this connection must be difficult. When all is said and done, the most obvious way of making use of atomic energy for road or rail vehicle propulsion is through the medium of an electric traction motor.

Development tendencies of modern carburettor fuels is the subject of a paper by H. Dietrichs in which he deals not only with those frequently discussed subjects, anti-knock requirements and octane numbers, but also with reformed petrols, octane requirements of engine types, carburettor icing, the knock problems of two-stroke engines and the knock phenomena at very high compression ratios. This, too, is an interesting clear and stimulating contribution.

Another paper is on the mixture supply of the Otto engine. It is by Prof. K. Löhner who deals with the complex subject in an exemplarily clear and unambiguous manner. In fact this can be considered as a classic example of a penetrating presentation of a difficult subject, since it is devoid of the academic verbiage that so often clouds the issue in similar circumstances. Next Dr. M. Rossenbeck deals with the interaction between fuel and engine, on the basis of extensive tests carried out over typical trunk roads and motorways as well as in cities. Of great importance and interest is the effect of truly representative average conditions encountered by automobiles, lorries and buses in terms of variables such as, on the one hand, speed, gear ratios, gear changes, engine r.p.m. and, on the other hand, the fuel consumption. So also are the effects of these variables on cylinder head and spark plug deposits, and in this connection, the author deals with the recording equipment used for the tests as well as with his findings.

The possibilities of modifying engine characteristics thermodynamically are considered by E. W. Huber, who approaches the problem by comparing the torque characteristics of the petrol engine with those of the steam engine. This poses the question as to whether transmission development towards ever increasing size, cost and complexity, for the sake of improved vehicle performance, could not be halted or at least slowed down by improving the engine characteristics, with particular reference to part load conditions. The author considers the potentialities, in respect of petrol engines, of the application of the extended expansion principle, described by him in some detail in Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 95, 1956.

Prof. F. N. Scheubel presents a paper on torque converters for terrestrial vehicles. He considers the effects of the engine characteristics and vehicle traction requirements on the demands imposed on transmissions. The action of both hydrokinetic and hydrostatic torque converters is dealt with in general terms, bringing out the significant points of fundamental importance to vehicle designers. Finally the author concludes that, in terms of weight, the hydrostatic converter is likely to be equal to the electric transmission although it is at least doubtful whether it will ever be built in such a wide range of sizes as has already the latter type.

In view of the avalanche pattern of the development of automatic and semi-automatic transmissions nowadays for road and rail vehicles everywhere, and because of the number of possible combinations and permutations that can be achieved with a torque converter, clutch, hydraulic coupling and various types of gear transmission, a paper clearly cataloguing and analysing the various systems in a clear, systematic and disinterested manner is long overdue. Director A. Majer has done just that, and the study of his contribution is a pleasure and an education. Now that Heldt's book on torque converters is gradually becoming out of date, whilst Semichatnov's volume, devoted mainly to design calculations of torque converters for diesel locomotives, is less broad in outlook and in any case available only in Russian or German, it is to be hoped that this paper will be expanded into a book, to fill the gap and meet a widely felt need.

The last paper, by H. G. Forster, deals with the engine characteristics, as affected by the transmission. One of the weaknesses of specialized development is that the overall solution frequently suffers as a result of the specialists preoccupation with the particular: vehicles have to operate most of the time at certain speeds and loads, and it is in these ranges that fuel consumption should be at its lowest; yet how many vehicle engines and transmissions are carefully matched to meet specific traction requirements, especially since the advent of hydraulic transmissions made the exercise, if not unduly complex, at least time consuming? The author sets out to clarify the situation by a comparative analysis of the transmission efficiencies and the effect on fuel consumption over the entire load range of a conventional gear type transmission, a transmission with a hydraulic coupling, and with hydrodynamic and hydrostatic torque converters. This should lead to a better appreciation and stimulate further action in this important field. It is, however, strange that among the twenty-three references, the name of Prof. A. Jante appears but once and then only in connection with a 1945 West German contribution. Jante has contributed some fundamental papers pertinent to this subject, originally in the East German monthly journal *Kraftfahrzengtechnik*, and reprinted in 1959 in Vol. 2 of *I.C. Engines and Automobiles*, pp. 605–647.

This interesting and useful volume might have been even more useful had the discussions of the papers been included. It is possible, however, that these were not up to the standard of the papers, especially since German engineering societies do not generally make available advance copies of the papers.

Untersuchungen von Sattelkupplungs—Gelenkzapfen (*Investigation of Saddle–Coupling Link–Pins*) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 136.

In German, by Otto Bode, Prof. Dr. Ing, Werner Görge, Dipl-Ing. and Eberhard v. Jähnichen.

Düsseldorf: VDI-Verlag G.m.b.H. 1960. 11¾ × 8¼. 31 pp. Price DM.21.60.

The rapid evolution of articulated road vehicles for small and large loads, and the use of road–rail vehicles and containers, military transporters and other special vehicles makes it more than ever necessary to arrive at a generally acceptable standard coupling or range of couplings graduated in certain agreed load ranges. That considerable economic benefits could be derived from such a measure is self-evident, yet the absence of appropriate action will make its implementation more expensive and difficult as time goes on. Because of this, the Federal Ministry of Transport has entrusted the Motor Vehicle Institute of the Technical High School at Hanover to provide basic data that could be used for the development of a standard coupling for all articulated vehicles, including those evolved for military duties.

In the report under review, the problems associated with the design and performance of a coupling, similar to the fifth-wheel kingpin standardized by the SAE in 1940, are outlined. Modern couplings, as used in the U.S, France, Italy, Holland, and a proposed German standard, are reviewed in some detail and this section is followed by one in which are discussed the requirements that should be specified for design. The next chapter deals with theoretical method for the determination of maximum stresses in kingpins, the stresses imposed on the adjoining components, and also with tests carried out to verify the conclusions relating to the stresses likely to be imposed on the saddle plates and the securing rivets.

Road tests were carried out to ascertain the stresses imposed on the kingpins, and the statistical analyses of the extensive results are summarized in graphical form, permitting rapid and unambiguous interpretation and conclusions. Finally, since operational experience has shown wear to be the major reason for kingpin replacement, rig tests were carried out to determine the wear rate of 2 in diameter kingpins. A special rig was evolved for this purpose and the pins tested over a range corresponding to 100,000 km at 40 k.p.h, 60 per cent under full load and 40 per cent empty, 15 per cent on good, 70 per cent on average and 10 per cent on poor roads, the remaining 5 per cent corresponding to traversing curves. The report concludes with a summary of the findings, which indicate the action to be taken by the designers of both tractors and trailers.

Reifen-Handbuch (*Tyre Handbook*)

In German, by G. Schulze.

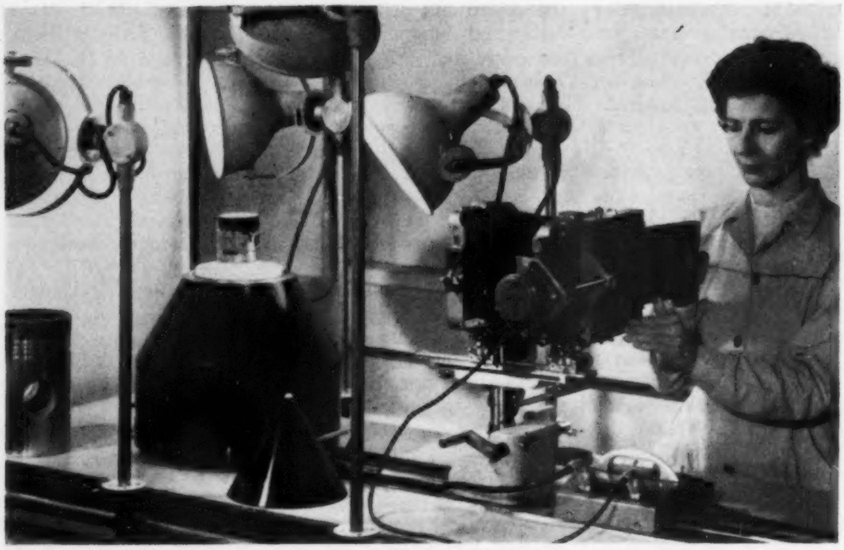
Berlin: VEB Verlag Technik. 1960. 8¼ × 6, 130 pp. Price DM.6.

The purpose of this handbook is to convey to vehicle owners and to all who have to deal with vehicle maintenance that tyres are a valuable component well worth looking after. As a preliminary to the achievement of this aim, the author deals briefly with the typical tyre configurations most widely used at present, and then gives an outline of tyre development, starting with the work originating from a complaint by the "son of the Scottish veterinary surgeon J. B. Dunlop". The designations of various tyre types and sizes are conveniently presented in tabular form.

In the second chapter are discussed the fundamentals of tyre mechanics, the load-carrying properties of air, the riding and road holding qualities of tyres, springing and damping characteristics, rolling resistance, noise, and profile patterns and their action. The third chapter is devoted to tyre manufacture, which is clearly and lucidly described with the aid of numerous illustrations. Next the author deals with tyre maintenance and tyre damage, stressing that some 30 per cent of all motor-cycle tyres, 51 per cent of all car and 60 per cent of all lorry tyres are prematurely scrapped because of inadequate maintenance, and these values are further considered in terms of the contributing factors.

Obviously, great care should be devoted to the treatment of what, by any standards, is not a cheap component. To this end the author deals at considerable length with tyre installation and removal, the effect of tyre pressure on the load, the effect of speed and methods of driving on tyre mileage, the influence of weather and the condition of the vehicle, the action of twin tyres, the storing of tyres and their repair. The fifth chapter deals with the rules governing the choice of tyres. Finally, there is a section to provide guidance in dealing with complaints regarding faulty tyres; this is based on the official publication *General Rules Concerning the Supply of Motor-car Tyres*.

This is an interesting book which, while written to meet the needs of a state owned and controlled industry in all its aspects, provides much good information for the general user and is likely to be of real value in reducing tyre replacement costs. The style of the work is lucid and informal.



By the addition of a special back assembly, this standard technical camera becomes a periphery camera. As the piston slowly rotates on its turntable, a photographic plate passes behind a narrow, stationary slit, and records a picture of the developed surface of it. The speed of the turntable and that of the plate are, of course, very closely inter-related

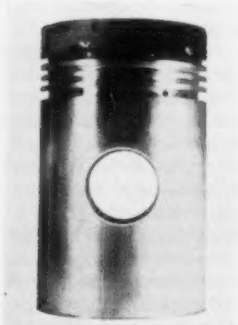
PHOTOGRAPHY OF CURVED SURFACES

Camera Developed by Shell Research Ltd. Has Many Applications in Automobile Research and Development

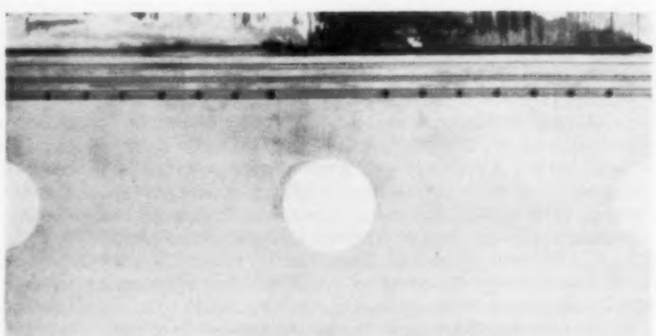
MOST engineers have been confronted, at some time in their careers, with the problem of accurately comparing and recording the conditions of worn or damaged cylindrical objects. In any vehicle, of course, the majority of components that suffer wear, erosion, pitting or discoloration have uniform curved surfaces, and the variety of effects on these surfaces is so wide that the vocabulary of the engineer is not always sufficient to express accurately the appearance of the damage. Although photography is normally one of the most reliable and widely used methods of recording these effects, the technique has some well-known shortcomings; lighting, for example, has to be carefully arranged so that there are no strong reflections from specimens with a bright finish, and small components are particularly difficult to photograph.

Attempts to overcome the limitations imposed by conventional photographic equipment have had varying degrees of success. For instance, one system involves taking a number of photographs of narrow strips round the whole 360 deg of the test surface, and mounting them side by side. In another technique, use is made of a curved film and a revolving lens assembly, but the obvious disadvantages prevented this from becoming a commercial success. All of the methods hitherto designed for the portrayal of a developed cylindrical surface on a single flat print have been characterized by restriction in their range of applications and sometimes by a degree of complexity that made them unsuitable for general industrial use.

In the laboratories of Shell Research Ltd, at Thornton, Cheshire, the need for an adaptable camera for periphery photography has been experienced for some time, since much of the work done there is on the behaviour, in service, of pistons, poppet valves, gear wheels, and bearing races, and the way in which they are affected by petroleum products under a variety of conditions. The laboratories have now



When conventional photography is employed, some of the details on this piston are obscured by bright reflections. With the periphery camera, however, the type of lighting can be chosen freely to emphasize the features that are of interest



developed a periphery camera that can be adapted to virtually any industrial need of the type outlined, and which does not require a high degree of skill for its operation.

A rotating specimen is photographed by a camera in which the light-sensitive plate moves transversely behind a narrow, stationary slit; the turntable on which the specimen is mounted rotates at a speed that is, of course, directly related to that of the plate. Since only a thin strip of the test surface is photographed at any instant and the axis of the camera is normal to it, the angle of lighting is not critical, and strong side-lighting can be used to emphasize surface imperfections.

The equipment used in this process includes a 4 in × 5 in standard technical camera, in which only the back assembly is specially designed; a standard double dark slide film holder is used. Both the camera and the turntable are mounted on a photographic bench, to obviate the risk of vibrations. A small synchronous motor is incorporated in the back assembly, and this drives the screw that actuates the holder for the traversing slide; the turntable is also driven by a synchronous motor which, together with the other, is operated by an electrical supply at 115 V and 50 c/s. One revolution of the turntable takes 3 min 12 sec; the time taken for the full travel of the plate is slightly longer than this, to allow for a margin of safety during starting and stopping.

Parts of the internal cylindrical faces of some components can be photographed with the periphery camera. This is done by raising the camera to a position from which it can view the remote face of the hollow member; distortions can then be reduced by adjusting the orientations of the lens panel and the back-panel. During such operations, of course, the direction of rotation of the turntable is reversed.

Probably the chief value of the Shell periphery camera is its ability to photograph the surfaces of components that depart from the perfect cylindrical shape. The width of the stationary slit is adjustable over a range between 0·040 in and 0·003 in, and any objects that are not perfectly circular, or have shouldered or grooved surfaces, can be photographed with all relevant faces in focus if the slit is made very narrow.

It is mainly in the photography of pistons that this periphery camera is of most value, for it is well-known that a great deal can be learned about the running behaviour of an engine from visual examination of its pistons. Three of the factors frequently taken into account are the wear pattern of the surface and grooves, the quantity and texture of carbon deposited, and the nature and colour of the lacquers formed. In conventional photography the appearance of all three can be seriously affected by the quality of the lighting, whereas in periphery photography a remarkably consistent level of recording is obtained with simple lighting. By the use of squared grids, superimposed on the photographs during printing, measurements can be made rapidly of the areas of carbon deposits.

Because of the consistency of the results, this method of photography is particularly useful in circumstances where a component is occasionally removed for examination and then returned to service. In cases such as these, a standardized lighting layout is obviously best for getting reliable results. Since, in the Shell equipment, the lamps are mounted on a photographic bench, and are fully adjustable for height and distance from the subject, a very close control of illumination can be maintained.

Components as large as heavy commercial tyres and as small as pencil leads can be accommodated. Obviously, the degree of reduction afforded by the lens must be related

The periphery camera can be used to photograph tapered and irregular surfaces; the problem of recording both at the same time arises in the case of this spiral bevel pinion

A faithful depiction of the condition of this taper roller race would be virtually impossible to achieve by any conventional method of photography

to the diameter of the subject, in order that the proportions of the resultant photograph are correct. In fact, the ratio of the plate's lateral travel to the circumference of the subject must equal the ratio of the distances between the lens and focal plane, and the lens and subject.

One very interesting use to which the technique can be put bears no relation to periphery photography. If true relative proportions along the two axes are not essential, it is possible to compress lengthy traces such as those produced by pen recorders, and thereby economise on filing space.

NEW BRITISH CARS

Summary of the Noteworthy Features of Recently Introduced Vehicles

SINGER VOGUE

A longer wheelbase, smaller wheels, a wrap-round type windscreen and paired headlamps are among the features that enable the Singer Vogue 1·6 litre car to be distinguished from the Gazelle

ALTHOUGH the new Singer Vogue four-door saloon is slightly larger than the well-established Gazelle models —which were described in the September 1959 issue of *Automobile Engineer*—it has certain affinities to them, and some components and assemblies are common to both types of car. By comparison with that of the Gazelle, the wheelbase of the Vogue is longer, by 5 in, which has a number of advantages, and the front wheel track is greater by 2½ in. Production has been rationalized by the employment of the 1,592 cm^3 engine already featured in the Sunbeam Alpine and Rapier cars, and also installed in the latest Gazelle and Hillman Minx models, to which brief reference will be made later. Relative to the earlier vehicles, the Vogue incorporates improvements to the engine mounting, the transmission and the suspension. An important advance is the virtual elimination of routine lubrication of the chassis. Following the present-day trend, paired headlamps have been adopted.

The unitary body-chassis structure follows orthodox Rootes Group practice. In spite of the substantially longer wheelbase, the overall length of the vehicle is only 1¾ in greater than that of the Gazelle; this means that the overhang has actually been reduced, particularly at the rear. Whereas the body shell is wider by 1½ in, the rear seat is in fact 3 in wider because the wheel arches are relatively further to the rear and are smaller, owing to the use of 13 in instead of 15 in diameter wheels. The ratios of wheelbase : overall length, wheelbase : mean track and mean track : overall width are respectively 0·623 : 1, 2·02 : 1 and 0·803 : 1.

In both seats, the elbow room is greater than in the Gazelle and, although the Vogue is lower owing to the smaller wheels, the rear passengers have slightly more headroom. The leg room in the front seat has been increased by 3 in, and advantage has been taken of the longer wheelbase of the Vogue to widen the front doors and to eliminate almost completely the cutaway of the rear doors to clear the rocker panels. Other styling changes include the adoption of a wrap-round windscreen, with normally raked pillars as on the Humber Hawk and Super Snipe models, and a considerable reduction in the width of the rear quarter pillars, with benefit in respect of the rearward view.

Since the spare wheel has been transferred from the boot to a cradle beneath it, and the 11 gal fuel tank is mounted transversely behind the rear squab, there is 14½ ft^3 of unobstructed luggage space. A neat appearance of the rear end has been obtained by recessing the lamp groups into the panelling. At the front, the horizontally paired Lucas sealed-beam headlamps are, perhaps, rather over-emphasized by heavy surrounding beading, part of which consists of a peak above the lamps.

Considerable attention has been devoted to ensuring efficient rust proofing and sound insulation of the body. The shell is phosphated before painting, and the underside is subsequently coated with a bituminous compound. Felt insulation is applied to much of the interior, including the floor and the roof, and there is a layer of plastics foam on the forward face of the dash.

Although the 1,592 cm^3 engine is, of course, basically the same as that of the Sunbeam cars mentioned earlier, it is less highly tuned: the cylinder head is of cast iron instead of aluminium, and the compression ratio has been reduced from 9·1 : 1 to 8·3 : 1. In addition, only one carburettor is specified, and the camshaft has less extreme characteristics, though the overlap is still greater than that of the earlier Gazelle engine.

Naturally, these differences have had their effect on the performance, but the engine of the Vogue is nevertheless superior to the 1,494 cm^3 unit, in respect of both power output and torque. The increase of 6½ per cent in swept volume is accompanied by a 10 per cent rise in the net b.h.p—at 200 r.p.m. higher rotational speed—and one of 4 per cent in the maximum torque. However, the speed at which the torque peak is reached has risen from 2,400 to 3,000 r.p.m.

The power output quoted is equal to just under 39 b.h.p/litre and to 1·91 b.h.p/in^2 of piston area. For the ratios of maximum torque : torque at maximum b.h.p, and speed at maximum torque : speed at maximum b.h.p, the figures are respectively 1·27 : 1 and 0·625 : 1. The engine produces 0·182 b.h.p/lb of its dry weight. Although the Vogue Saloon is over 1½ cwt heavier than its Gazelle counterpart, its power : weight ratio of 56·6 b.h.p/ton kerb weight is about 2 per cent higher.

At the rear of the power unit, a single rubber-in-shear mounting replaces the two-point arrangement employed for

the 1,494 cm³ engine. Since the new layout provides less resistance to rock under torque reaction, a damping device has been introduced to afford additional torsional stiffness. This device consists of a bracket bolted to the rear end of the cylinder head, and two opposed rubber cones mounted on the dash; the trailing end of the bracket is positioned between the apices of the cones.

As in the case of the Gazelle and Hillman Minx, there is a choice of a four-speed, manually controlled gearbox, with or without overdrive, or the Smiths Easidrive automatic transmission; the relevant details of both types are given in the data table. It is noteworthy that first and second gears of the Easidrive transmission are rather lower than hitherto. The hypoid bevel final-drive unit has a ratio about 8 per cent higher than that of the earlier Gazelle, to compensate for the smaller rolling diameter of the tyres.

Of considerable interest is the Metalastik bonded type rubber coupling embodied in the rear universal joint of the propeller shaft. The inner and outer sleeves of this coupling are flanged for bolting to corresponding flanges on the driven yoke of the universal joint and on the pinion shaft respectively. It is claimed that the coupling eliminates transmission boom and absorbs high-frequency, road-excited vibrations, as well as introducing some additional resilience into the drive. On account of the longer wheelbase, the diameter of the propeller shaft, 3 in, is ¼ in greater than in the case of the Gazelle.

The rear springs are 3 in longer than those of the Gazelle; both the roll stiffness and the lateral location of the axle have been increased by widening the leaves from 1¾ in to 2 in. In the interest of quieter running, the rubber bushes in the leading eyes of the springs are of the Metalastik Metaxentric type. No basic departure has been made from the familiar Rootes front suspension layout of semi-trailing wishbones, and coaxial coil springs and dampers. However, the spring rate has been increased, and use is made of rubber bushes at the inboard pivots and sealed, nylon seated ball joints at the outboard ends and on the track rod assembly, to eliminate all the grease nipples. The only remaining nipples on the chassis are one on each universal joint of the propeller shaft, one for the bearing of the slave lever of the track-rod assembly, and one on the handbrake cable.

A rate of 130 lb/in is quoted for the rear springs, and the periodicity at the rear is 86 c/min in the static laden condition. The roll centre height is 10½ in, and the roll stiffness is 200 lb-ft/deg. For the front suspension the figures for the rate and periodicity are 125 lb/in, measured at the wheel, and 114 c/min; the roll centre is just below ground level, and the roll stiffness is 267 lb-ft/deg.

As was stated earlier, the larger-bore engine is also installed in the latest Gazelle and Hillman Minx models. It differs from the version in the Vogue, however, in having the same camshaft as the 1,494 cm³ unit formerly employed, and a Zenith 30VN carburettor of 23 mm choke diameter. Because this diameter is less than was previously employed on either the Singer or Hillman versions of the smaller engine, the net power output of 52·8 b.h.p. at 4,500 r.p.m. is, in fact, appreciably lower than that of the first-mentioned unit, though it is much the same as the figure quoted for last year's Hillman Minx. On the other hand, the maximum torque of 86·8 lb-ft is markedly better than the 83 lb-ft of the smaller engine, and is produced at a lower speed—2,100 r.p.m. instead of 2,400 r.p.m. Consequently, the latest cars should have substantially improved acceleration over the most frequently used portion of the speed range.

In the case of models supplied with the manually controlled gearbox and overdrive, the 4·86:1 final-drive ratio is retained; with the other two forms of transmission, however, the ratio has been raised from 4·44:1 to the 4·22:1 of the Vogue. Among the other changes are the adoption of lower first and reverse ratios in the four-speed gearbox, and of a reinforced front cross member. Four grease nipples have been deleted from the track rod linkage by the use of ball joints with nylon seatings. It is noteworthy that the prices of both ranges have been substantially reduced.

SPECIFICATION DATA

Engine
Number of cylinders 4
Bore 81·5 mm
Stroke 76·2 mm
Swept volume 1,592 cm³
Compression ratio 8·3 : 1
Maximum b.h.p. (net) 62 at 4,800 r.p.m.
Maximum b.m.e.p. 133 lb/in² at 3,000 r.p.m.
Maximum torque 85·8 lb-ft at 3,000 r.p.m.
Crankshaft Three-bearing, forged steel
Cylinder head Cast iron with modified bath tub type combustion chambers and vertical, push rod operated valves
Carburettor Solex 32 PBIS, with 25 mm choke
Fuel pump AC mechanical
Dry weight 340 lb, including clutch

Transmission
Clutch Borg and Beck single dry plate, 8 in diameter, with standard transmission only
Gearbox Standard: four-speed, manually controlled gearbox, with synchromesh on second, third and fourth; Laycock-de Normanville overdrive available as optional extra, effective on fourth and third gears. Alternative: Smiths Easidrive automatic three-speed transmission, embodying two magnetic particle couplings

Gear ratios, standard

	Normal	Overdrive
fourth	1 : 1	0·803 : 1
third	1·392 : 1	1·117 : 1
second	2·141 : 1	
first	3·346 : 1	
reverse	4·239 : 1	

Gear ratios, automatic

third	1 : 1
second	1·60 : 1
first	3·24 : 1
reverse	3·36 : 1

Dry weight, including bell housing

standard	68 lb
standard with overdrive	89 lb
automatic	170 lb

Propeller shaft B.R.D. open, with needle roller bearing universal joints; Metalastik bonded rubber coupling embodied in rear joint

Rear axle
Type Semi-floating, with hypoid bevel reduction
Ratio

standard	4·22 : 1
standard with overdrive	4·44 : 1
automatic	4·22 : 1

Suspension
Front Semi-trailing double wishbones, with coaxial coil springs and Girling or Woodhead-Monroe telescopic dampers
Rear Semi-elliptic leaf springs, with Girling or Woodhead-Monroe telescopic dampers

Steering
Type Burman recirculating-ball
Ratio 14·5 : 1
Turning circle 36 ft
Turns from lock to lock 3·15

Brakes
Front Lockheed hydraulic, with 9 in diameter drums and twin leading shoes, 1¾ in wide
Rear Lockheed hydraulic, dimensions as at front but leading and trailing shoes. Mechanical actuation by handbrake
Total swept area 198 in²
Distribution of braking effort
front 64 per cent
rear 36 per cent

Wheels and tyres
Wheel type Pierced, pressed steel disc, with four-stud attachment and 4½ in wide rims
Tyres Dunlop 5·90—13 in tubeless
Pressures, normally laden
front 27 lb/in²
rear 30 lb/in²

Dimensions
Wheelbase 8 ft 5 in
Front track 4 ft 3½ in
Rear track 4 ft 0½ in
Overall length 13 ft 9¼ in
Overall width 5 ft 2¼ in
Overall height 4 ft 10¼ in
Ground clearance 6½ in
Frontal area 19 ft²
Kerb weight 2,455 lb, with full petrol tank
Weight distribution
front 55 per cent
rear 45 per cent

TRIUMPH TR.4

THE Triumph TR.4 sports car, which is slightly larger than its TR.2 and TR.3 predecessors, retains the separate chassis frame and body type of construction. Of the engine modifications, the most important is an increase of the swept volume from 1,991 cm³ to 2,138 cm³. A new gearbox has been developed, which has synchromesh on all four forward ratios; it is stated by the manufacturers that the TR.4 is the first British car in quantity production to embody this desirable feature. The suspension and braking systems are generally similar to those previously employed, but a rack and pinion steering unit replaces the cam and peg type. In the lines of the body, which incorporates an occasional rear seat for children, a good compromise would appear to have been struck between aerodynamic and styling considerations.

The 2·1 litre engine is based on the unit that has already proved itself in international sporting events. It has the same stroke as hitherto but the bore has been increased from 83 to 86 mm, giving a stroke : bore ratio of 1·07 : 1. A

factor contributing to longevity is the use of wet cylinder liners, which are readily replaceable. No change has been made to the cast iron cylinder head, or the sizes of the valves and the S.U. carburettors, but the piston design has been modified to raise the compression ratio from 8·5 : 1 to 9·0 : 1. As a result of the modifications, the speed for maximum gross power has fallen by 250 r.p.m, whereas that for maximum torque has risen by 350 r.p.m.

For a 7·3 per cent increase in swept volume, the power output has risen by 5 per cent and the torque by 8 per cent. The gross b.h.p/litre figure of 49·2 is thus slightly lower than that of the old engine, as is that of the b.h.p/in^2 of piston area. However, since the weight of the vehicle is only a few pounds more than that of the TR.3 and the drag coefficient is slightly lower, the TR.4 should have not only appreciably better acceleration but also a higher maximum speed. The ratios of maximum torque : torque at maximum b.h.p. and of speed at maximum torque : speed at maximum b.h.p. are respectively 1·09 : 1 and 0·706 : 1, and the power : weight ratios are 0·231 b.h.p/lb of the engine dry weight and 108 b.h.p/ton of the kerb weight of the complete car.

In addition to having synchromesh of the baulk ring type on all forward speeds, the new gearbox differs from its predecessor in respect of ratios for the first and reverse gears. The increased engine torque has permitted the first gear ratio to be raised by about 8 per cent, and reverse is of course similarly higher than before. As on the TR.3, Laycock-de Normanville overdrive is available as an optional extra. Although the general design of the rear axle is unaltered, the track is larger.

Because of the increased lateral stability afforded by the track increase—4 in at the front and 3 in at the rear—it has been found possible to soften the bump settings of the front and rear dampers, thus improving the response of the suspension. The camber of the rear springs has been altered to increase the bump travel. In view of the excellent steering of the Triumph Herald, the change to a rack and pinion mechanism for the TR.4 is not surprising. The layout is similar to that of the Herald, in that the rack unit is mounted in front of the engine, to permit adequate raking of the steering column; however, the outboard ball joints of the tie rods require routine lubrication. Another Herald feature adopted is the praiseworthy Impactoscopic steering column, which was described in detail in the October 1960 issue of *Automobile Engineer.*

Details of the suspension systems are given in the accompanying data table. In the case of the front suspension, the spring rate at the wheel is 106 lb/in, the periodicity is 83 c/min, and the roll centre height and roll stiffness are respectively ¾ in and 185 lb-ft/deg. No anti-roll bar is fitted as standard, but one will be offered as an optional extra; it increases the roll stiffness by 117 lb-ft/deg. The corresponding figures for the rear suspension are 128 lb/in, 97½ c/min, 9½ in and 127 lb-ft/deg.

In effect, the chassis frame is a modified TR.3 assembly, provision for the increased front track consisting of the addition of a channel member to the outboard side of the leading end of each side member. No change has been made to the transverse spacing of the side members, or to the cruciform bracing member. The bodywork is of steel, with detachable front wings, and is noteworthy in several respects. Following the tradition of the previous TR cars, the headlamps, instead of occupying the conventional position in the front wings, are mounted further inboard, where they blend neatly into the shallow radiator grille. Since

SPECIFICATION DATA

Engine
Number of cylinders 4
Bore 86 mm
Stroke 92 mm
Swept volume 2,138 cm^3
Compression ratio 9·0 : 1
Maximum b.h.p. (gross) 105 at 4,750 r.p.m.
Maximum torque 126·7 lb-ft at 3,350 r.p.m.
Maximum b.m.e.p. 147 lb/in^2 at 3,350 r.p.m.
Crankshaft Three bearing, forged steel
Cylinder head Cast iron, with bath tub type combustion chambers and vertical, push rod operated valves
Carburettors Two S.U. H6 semi-downdraught, with 1¾ in diameter throttle barrels
Fuel pump AC mechanical
Dry weight 456 lb, including clutch

Transmission
Clutch Borg and Beck single-dry-plate, 9 in diameter, with hydraulic actuation
Gearbox Four-speed, with synchromesh on all forward ratios. Laycock-de Normanville overdrive optional extra, giving 0·82 : 1 step-up on fourth, third and second gears
Gear ratios

fourth	1 : 1
third	1·325 : 1
second	2·01 : 1
first	3·139 : 1
reverse	3·223 : 1

Dry weight 74 lb, including bell housing; overdrive adds 31 lb
Propeller shaft Hardy Spicer open type, with needle roller bearing universal joints

Rear axle
Type Semi-floating, with hypoid bevel reduction
Ratio 3·7 : 1 or 4·1 : 1

Suspension
Front Double transverse wishbone type, with coaxial coil springs and Armstrong telescopic dampers
Rear Semi-elliptic leaf springs, with Armstrong lever type dampers

Steering
Type Alford and Alder rack and pinion
Turning circle 33 ft
Turns from lock to lock 2½

Brakes
Front Girling hydraulic disc type, with 11 in diameter discs, total swept area, 267 in^2
Rear Girling hydraulic drum type, with 9 in diameter drums, and leading and trailing shoes, 1¾ in wide; total swept area, 99 in^2. Mechanical actuation by hand-brake
Distribution of braking effort
front 65½ per cent
rear 34½ per cent

Wheels and tyres
Wheel type Pressed steel disc, with four-stud attachment and 4 in wide rims; quickly detachable wire wheels optional extra
Tyres Dunlop, 5·90 — 15 in; Michelin X, Dunlop Duraband or Dunlop RS5 optional extra
Pressures, normally laden
front 22 lb/in^2
rear 24 lb/in^2
These pressures apply only for the standard tyres and must be increased for high speeds

Dimensions
Wheelbase 7 ft 4 in
Front track 4 ft 1 in with disc wheels, 4 ft 2 in with wire wheels
Rear track 4 ft 0 in with disc wheels, 4 ft 1 in with wire wheels
Overall length 13 ft 0 in
Overall width 4 ft 9½ in
Overall height 3 ft 10 in with hood up
Ground clearance 6 in
Frontal area 16 ft^2
Kerb weight 2,185 lb with full petrol tank
Weight distribution
front 53 per cent
rear 47 per cent

Although the body lines of the TR.4 have little in common with those of earlier Triumph sports cars, a family resemblance is given by the faired headlamps, which are mounted further inboard than is usual today. The swept volume of the engine is greater than that of the TR.3, synchromesh is now provided on all forward gears, and the track and body width have been increased

their bezels project slightly above the grille, fairings for them are embodied in the bonnet lid, which is frontally hinged and is counterbalanced to avoid the need of a stay to retain it in the open position.

Although the overall width of the body is only 2 in greater than before, and headroom has not been reduced, the increased track and altered lines give the car a considerably lower and broader appearance. The boot is considerably enlarged, to $5\frac{1}{2}$ ft^3, and there is useful additional space behind the front seats if the vehicle is used purely as a two-seater. On the basis of the dimensions quoted in the table, the ratio of wheelbase : mean track is 1·82 : 1, that of wheelbase : overall length is 0·564 : 1, and that of mean track : overall width is 0·843 : 1.

Map pockets are incorporated in the wide doors, which now have winding windows. A large, wrap-round rear light is embodied in the folding hood, which is standard equipment; considerable care has been taken to ensure ease of erection and stowage of the hood, as well as freedom from noise and draughts when it is raised. The hood sticks are stowed in the back of the padded squab of the occasional seat.

At extra cost, a hardtop version of the TR.4 will be available. Unusually, the hardtop consists of two units, the rear light portion and the roof panel. The rear light itself is of the wrap-round type, and its framing is bolted to the rear decking of the body. At the sides, the leading edge of the latter unit forms guides for the windows of the doors. The roof panel, which is internally trimmed and is made of steel sheet, is bolted to the rear unit and to the windscreen. It can be readily removed if desired, however, leaving the rear light *in situ* to eliminate back-draughts, otherwise inevitable in an open vehicle. In the event of rain during a run without the roof panel, or for quickly covering the vehicle when it is parked, a plastics-coated fabric panel with folding stiffeners—referred to by the company as the Surrey top—can be fitted over the opening, in a matter of seconds, to give full protection.

Winder-controlled windows on the doors replace the sidescreens of the earlier cars. The hardtop illustrated here is in two portions, the metal roof panel being individually detachable

Ultra-Thin Whitemetal

UNTIL about ten years ago, whitemetal was the most commonly used lining material for main and big-end bearings of petrol engines. Generally, the shells comprised about 0·010 in of whitemetal on a steel backing. The advantages of whitemetal are that it is relatively soft, can embed dirt easily, and the rate of crankshaft wear with it is low. It is also good so far as conformability is concerned and is not corrosively attacked in service. However, it has the disadvantage of low fatigue strength.

With the trend towards higher engine speeds and compression ratios, there has been a tendency to change to overlay plated copper-lead or tin-aluminium bearings. Not only are these bearings more costly but also, in some instances, it is necessary to employ harder and more expensive shafts to avoid an undesirably high rate of wear. Therefore, engineers have been seeking to adapt whitemetal bearings for carrying the increased loads. If the thickness of lining of whitemetal on a steel backed bearing can be reduced, its strength is increased because the soft metal obtains more support from the steel backing. This factor has led to the development of bearings in which the thickness of the whitemetal lining is only about 0·005 in. The additional strength thereby obtained is about 20 per cent.

Now, The Glacier Metal Co. Ltd, of Alperton, Wembley, Middlesex, has perfected a new manufacturing process for making whitemetal bearings with a lining thickness of only 0·003 in, with close control over this thickness. Close control is essential because, if the thickness is allowed to fall below 0·002 in, the wear properties will be impaired owing to inability of the lining to embed dirt. These ultra-thin whitemetal linings have a fatigue strength 50 per cent higher than that of standard whitemetal bearings.

So far as strength is concerned, these bearings fill the gap between the soft ones previously available and the stronger and harder lining metals such as copper-lead and reticular-tin-aluminium alloy. If standard whitemetal bearings are regarded as representing 100 per cent fatigue strength, the others compare with them as follows: thin whitemetal 120 per cent; ultra-thin whitemetal, 150 per cent; plated copper-lead, 190 per cent; reticular-tin-aluminium alloy, 250 per cent. Obviously, because of the availability of the new material, engine designers will be able to select a bearing to suit their individual requirements, without having to use a material that is really too strong and, therefore, harder than they really need. In some instances, too, it will still be possible to use whitemetal for big-end bearings.

Deep Drawing Research

FOLLOWING the highly successful Colloquium on Forming and Testing of Sheet Metal, held in Paris in May 1960, it is planned to hold another meeting next year. This will take place in Düsseldorf on 23rd and 24th May 1962, under the joint aegis of the International Deep Drawing Research Group and the Verein Deutscher Eisenhüttenleute.

The opening sessions of this meeting will be on the following two themes: speed effects in sheet metal forming; the influence of surface conditions on deep drawing. Of these two, the first will include the following three sections: effect of speed of deformation in deep drawing or other sheet forming processes; forming at very high speeds; explosive forming. The second covers effects of sheet metal surfaces, including metallic and non-metallic coatings; influence of tool surfaces; lubricants and lubrication.

Those wishing to contribute papers for discussion at this meeting are requested to forward, before October 1961, the titles, short summaries and the names of the author or authors, to either of the following addresses: John Hooper, Esq, Secretary, I.D.D.R.G, John Adam House, John Adam Street, Adelphi, London, W.C.2, or Geschäftsführung des Vereins Deutscher Eisenhüttenleute, Düsseldorf, Breite Str. 27. Authors will be advised by 15th November 1961 as to whether their papers have been found acceptable.

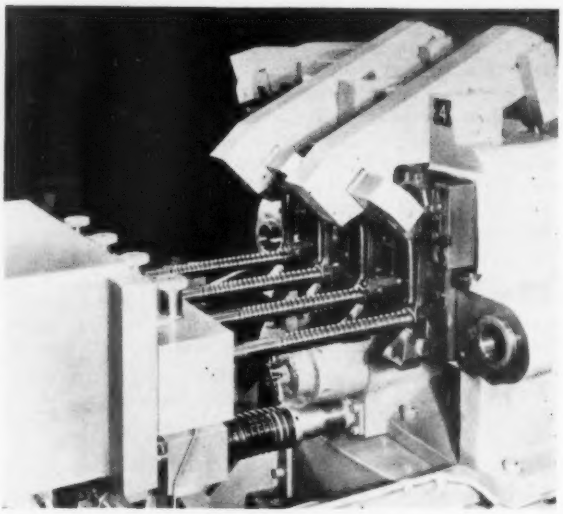
Machining Connecting-rod Small-end Bores

Multiple Broaching Equipment Included in Cross Co. New 6-Station Rotary-transfer Machine

AN investigation in the U.S.A. into the cost of machining the small-end bores of automobile engine connecting rods showed that economies could be effected by finishing the bores by a broaching operation instead of the more common reaming operation. It was found that broaches maintain their effective sharpness longer than reamers, so that improved finish is obtained with less frequent interruptions of production and less tool maintenance. The longitudinal tool marks remaining after broaching provide an admirable seating for the gudgeon pin bushing. With this new rotary-transfer machine, specially developed by the Cross Co, of Park Grove Station, Detroit 5, Michigan, work of better and more consistent quality is being produced at lower specific cost than is obtainable by the more conventional methods, it is reported.

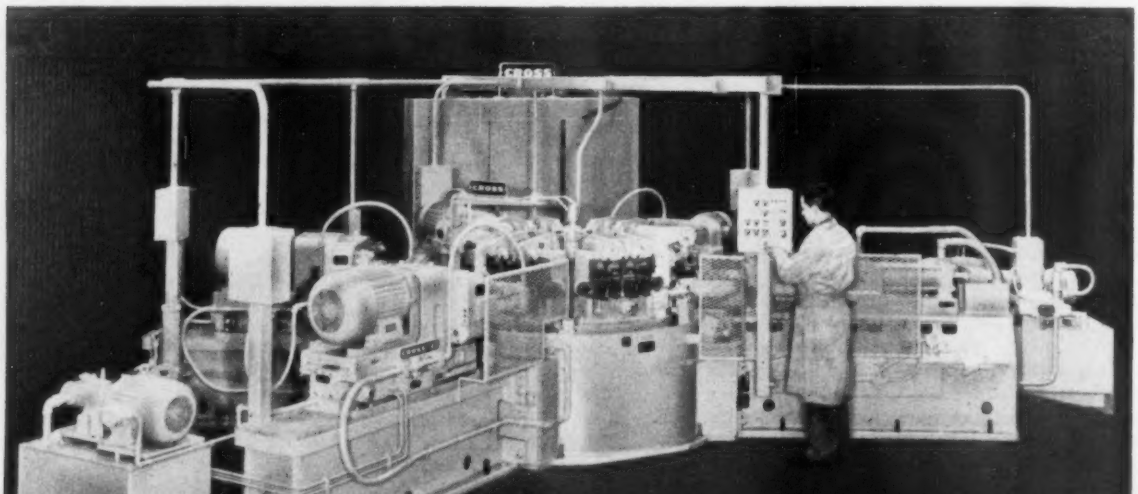
Operating at 80 per cent efficiency, this six-station machine will drill and finish the small-end bores of 500 connecting rods per hour. Although the forged-steel rods have a hardness value ranging between 197 and 241 Brinell, the finish diameter tolerance of $\pm 0{\cdot}0007$ in is maintained without difficulty. The indexing rotary table of the machine carries six work-holding fixtures, each accommodating four rods.

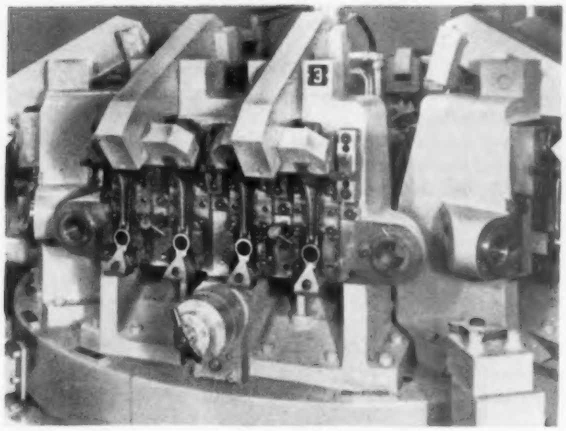
At the first station the operator loads four rods in the fixture and actuates the hydraulic clamping mechanism. The table indexes, and at the next station the small ends of the rods are drilled to half depth. With drills of slightly smaller diameter, the parts are drilled through at the third station, and at the fourth station are core drilled ready for the broaching operation. The fifth station is tooled with automatic recessing-tool holders and formed bits to chamfer both ends of all the four holes in a simultaneous operation.



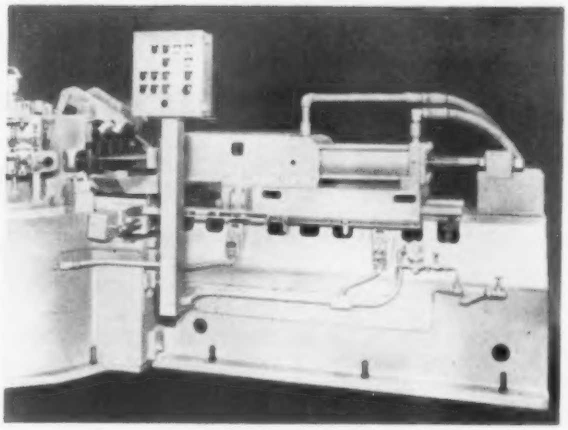
At the broaching station a coolant connection is established automatically. Coolant is passed through the fixture to both ends of the broached holes

Rotary-transfer machine developed by the Cross Company of Detroit. Connecting-rod small-ends are drilled, chamfered, broached and burnished





Work is held in multiple fixtures by hydraulic pressure-balanced clamps. Below the clamp actuation valve is the coolant check valve



An inverted type hydraulic feed unit actuates the broach head. The cylinder slides on guideways, over a rigidly mounted stationary piston

Broaching is carried out at the sixth station, and as the broaches approach the workpieces a pilot on the end of each broach enters and centres each broach in its hole individually. Broaches are formed with roughing and finishing teeth in the usual manner and the speed of operation is 30 ft/min. The finishing teeth are followed by two ball burnishers which size the holes; 0·0003 in of stock is left in the holes by the broaches for this purpose. Before the burnishers pass through the hole a rear pilot on each broach enters the hole to prevent the broach dropping out of centre as it starts on the return stroke. While the burnishers are provided to refine the surface finish of the hole they also slightly enlarge it from the broached diameter, thus ensuring that there is no drag on the cutting teeth of the broach during withdrawal.

Although most elements of this rotary-transfer machine are standard component units, the incorporation of a broaching station—claimed to be the first example—has introduced some special design features. The worktable is 60 in diameter, the broaching stroke is 18 in, and a pushing force of 4,700 lb is exerted. To ensure a straight-line application of force from the hydraulic cylinder to the broach head, the usual constructional arrangement has been inverted. The cylinder is mounted on the slide and the piston rod is secured to a rigid member on top of the otherwise standard wing pedestal. As the broach head is fed forward, a dog on the slide actuates gravity-operated cam clamps to lock the indexing worktable during the broaching operation. When the slide retracts the table clamps are released.

Each fixture on the table has a coolant connection fitted with a self-closing check valve. At the broaching station a connector is fed forward with the broach head. When connection has been established, coolant flows through the fixture and is directed on to the broaches as they enter the work and also as they emerge beyond the holes. This second delivery of coolant makes sure that chips will not be dragged back through the finished holes by the broaches on withdrawal. The function of the check valves is important. Coolant must be immediately available at the broaching station and the lines must, therefore, be held fully charged.

It is expected that the useful working life of this machine will be long. The fixtures are replaceable and could be readily changed for connecting rods of different design or for similar components. Critical wearing surfaces are fitted with replaceable carbide strips. In general, the successful use of broaching in this application illustrates that most machining operations can be performed effectively on rotary transfer machines. At the same time it demonstrates that such special processing machines can reduce the number of operations and handling of workpieces and thus lower production costs.

Mixer for Laboratory Use

DETAILS have been received of a new vertical mixer that has been developed by the Atlantic Research Corporation, of Alexandria, Virginia, U.S.A. This equipment, which bears the designation 60 LP, is intended for laboratory use and is suitable for mixing high-viscosity fluids and castable polymers. Thorough mixing is ensured by the use of two synchronized, meshing blades, and of close tolerances within the 60 in^3 mixing chamber, which embodies vacuum connections and is jacketed to permit accurate control of the temperature.

All parts in contact with the mix are of stainless steel and, to avoid any risk of contamination, the bearings are situated outside the chamber. The lid is of transparent plastics material, thus permitting observation while the mixing is in progress, and is sealed by a large-diameter O-ring. Mixing speeds can be varied from 50 to 250 r.p.m, and the unit can be readily dismantled for cleaning whenever necessary.

Dry Cells and Batteries

THE NATIONAL Bureau of Standards, U.S. Department of Commerce, has published its Handbook 71, entitled *Specification for Dry Cells and Batteries*. This handbook, which is the seventh edition of the specification, supersedes NBS Circular 559, of 1955. It has been necessitated by the introduction of a number of new types of battery and by the improved performance now obtained in many instances.

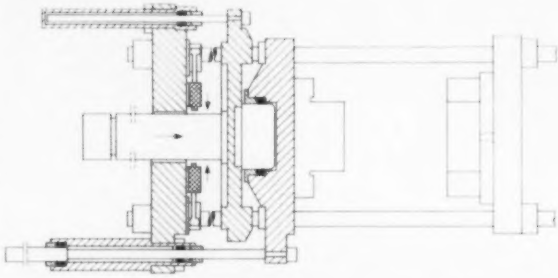
For the first time, the specifications are given for dry cells and batteries intended for use with transistorized circuits. Another innovation is the inclusion of metric dimensions, and of the cell designations adopted by the International Electrochemical Commission. A detailed description is given of the test methods for rating dry cells, and of the specifications for the construction and performance of the various types of cell. Copies of the handbook are obtainable from the U.S. Government Printing Office, Washington 25, D.C. The price is 25 cents, plus postage.

Triulzi 2,200-ton Pressure Diecasting Machine

Successful Proving Test on Production of Aluminium Four-cylinder Block for the Volga 2½ litre 80 b.h.p. Engine

A REPUTATION for the production of large pressure diecasting machines is rapidly being established by the Italian firm A. Triulzi, of Novate, Milan. In April, 1955, the then largest model, having a clamping pressure of 1,000 tons, was described in these columns; in July, 1960, a 1,500-ton machine; now the performance of a 2,200-ton model can be reported. This machine, designed and developed to Russian order, recently ran its proving and acceptance tests at the builder's works. The tests culminated in a continuous run over the period of a working week of five days, operating 24 hours per day under simulated production conditions. They also served to prove the massive dies, built by the Triulzi associated company, Fonderpress Di Gamberini Tagliavini, of Bologna, for the cylinder block of the 2,446 cm^3, four-cylinder engine of the Volga car. At the conclusion of the tests the machine was dismantled for immediate shipment to a plant in Gorkii, U.S.S.R.

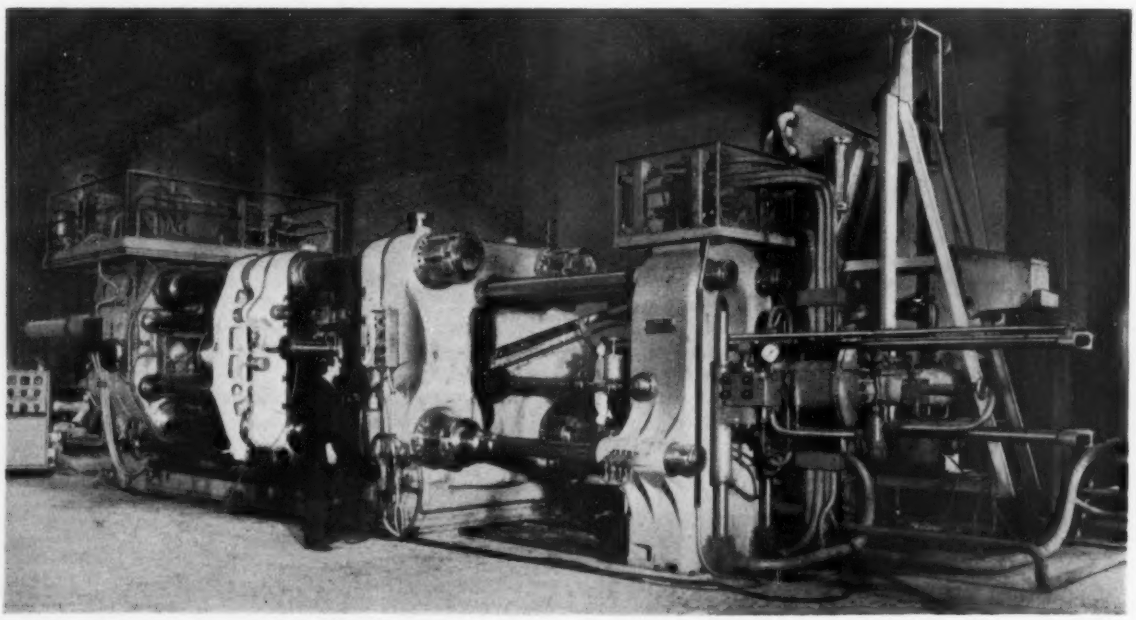
Considerable interest attaches to the casting, which has approximate overall dimensions of 20 in long, 13½ in high and 10½ in wide (11¾ in over the timing case). As it comes off the machine complete with runners and slug it weighs 48·4 lb, but when trimmed its net weight is 39·6 lb; a reduction of 18 per cent. The cylinder block had already been in production as a gravity casting, it is understood. Under final production conditions the diecast version will be heat-treated for stabilization and every casting, to insure against risk of porosity, will be impregnated in the production line.



Diagrammatic arrangement of the positive mechanical blocking device

For the purpose of the tests at the Triulzi works the aluminium alloy used had the following percentage composition: silicon 8·75, manganese 0·4, magnesium 0·3, iron 0·4, copper 0·119 and nickel 0·02. This alloy was found, at high injection velocities, to have a tendency to weld to the die. Under production conditions in Russia a different alloy, more akin to the British alloy LM9, will be used. Significant elements of the Russian alloy composition are likely to be: silicon 12·0, manganese 0·5, magnesium 0·5,

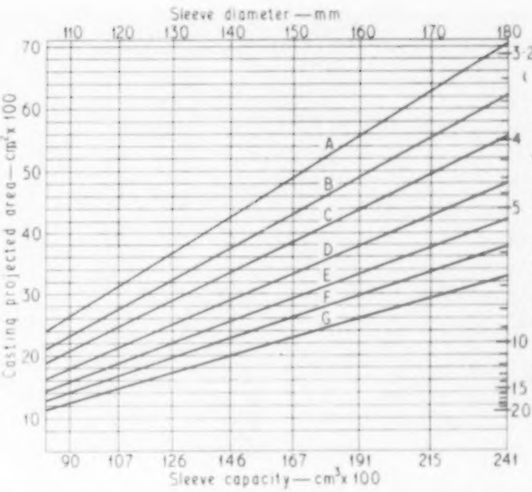
The 2,200-ton machine set up for trials at the Triulzi works at Milan. Dimensions are 54 ft 2 in × 12 ft 2 in × 17 ft 5 in. Weight is 113 tons



and iron at least 0·8 per cent. The copper constituent will be reduced in order to improve the resistance of the metal to corrosion.

The casting is gated low to the inner edge of the sump flange on the right-hand side of the block, as viewed from the rear or drive end. Total area of the gate is 4·6 cm², divided into four narrow slots. As a consequence, the slug and the runner are readily detached from the casting by a knock. During the tests the pressure on the metal in the die was 890 kg/cm². With an injection ram of 150 mm diameter an injection force of approximately 145 tons was applied. This would suffice to produce a casting having a projected area of 2,500 cm², considerably larger than that of the Volga cylinder block—approximately 1,750 cm².

While on test the machine, which will "dry cycle" at rates up to 120 per hour, was operated on cycle times of from 3 to 4 minutes. The actual freezing time was 35 seconds. Some time was expended each cycle in examination, air-blasting, and ensuring adequate lubrication of the die. When the die is thoroughly run in the machine will cycle to produce 20 to 22 castings per hour in regular operation.

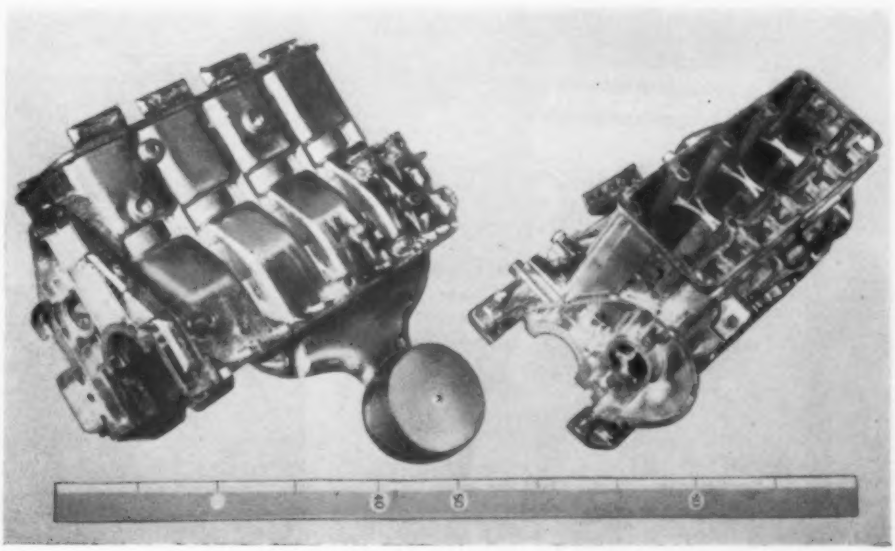


Nomogram of machine capacity and performance, relating injection force with casting area, sleeve capacity and pressure on the metal. Injection force (tons): A-80; B-90; C-101; D-117; E-133; F-148; and G-170

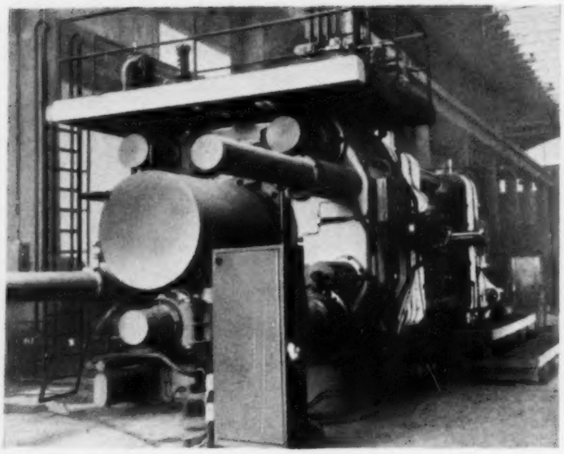
The lubricant used for the die, and also for the injection plunger, was a mixture of oil and graphite. A relatively slow injection ram speed was employed during the trials due to the welding tendency of the metal used, as mentioned earlier. The new alloy to be used in Russia, having an increased percentage of iron in its composition, will permit operation at higher injection velocities.

In general design the block represents a departure from current trends in light alloy units. It is usual to use a cylinder structure, or at least diaphragm walls, to brace the water jacket and add stiffness to the general structure and rigidity to the case carrying the main bearings. Cylinder sleeves are either cast in, shrunk in, or pressed in. To use a completely open and unbraced jacket and inset, wet-type liners would appear to be taking a somewhat larger stride forward than is customary in such matters. However, in view of the heavy capital investment in the means of production, it must be inferred that the step was taken after a

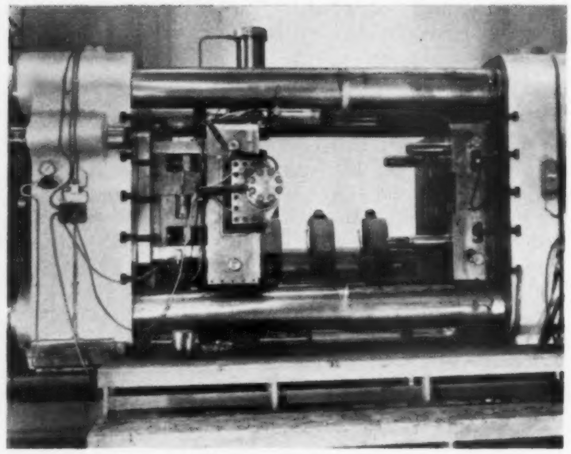
Above: The moving platen and the sliding support for the main column, shown in the retracted position



Right: The Volga aluminium cylinder block; shown with runners and slug as it is ejected from the machine



View of the main reaction head. Die height adjustment is by motorized actuation of the tie-bar nuts. The range of movement provided is 19¾ in

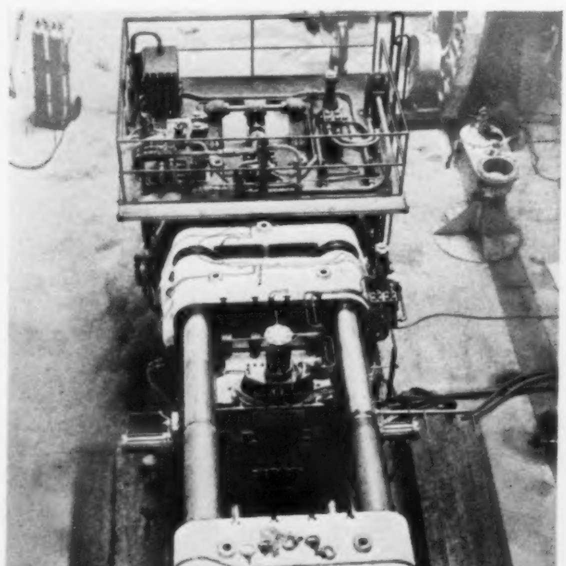


When the die is fully opened there is easy access for inspection of cavities. Clear space between the 11 in diameter tie bars is 51 in

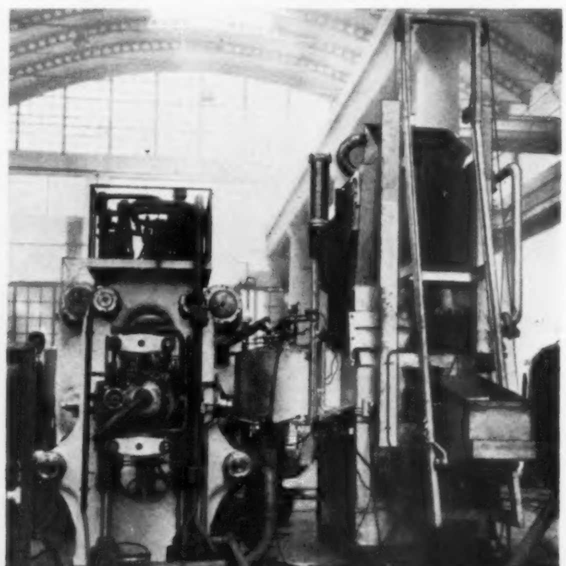
most thorough study of the possibilities and with complete confidence. The cast iron cylinder liners are of thick wall, shouldered, low-seating type with upper flanges aligned in the plane of the cylinder head joint face, as have been used for some years in certain European engines having cast iron cylinder blocks. The line drawing shows the structural arrangement and the few dimensions included serve to give scale and to indicate such features as wall thickness and machining allowances on the main faces.

Fonderpress, the builders of the die, maintained the closest collaboration with the Russian designers and Triulzi engineers in the planning of this project. Total weight of the die is approximately 13·5 tons and it is reported to have required 15,000 working hours to produce. It is made in Marathon E 38 die steel and hardened to 45 deg Rockwell. The metal composition is: carbon 0·4, silicon 1·0, manganese 0·5, chromium 5·6, molybdenum 1·0, and vanadium 0·5 per cent. Cooling by means of circulating water is provided for the die; a predetermined temperature being maintained by thermostatic control. During the trials the die was operated at a temperature of 230 deg C in the approximate centre of the cavity. If for any reason the die should become overheated a frame of five air conduits can be swung about a horizontal axis, to direct jets of air over the die cavity walls and rapidly lower their temperature. The arrangement can be seen in the illustration

Overhead view of the machine, showing the hydraulic equipment on the reaction head entablature, and the core actuation cylinders on the die



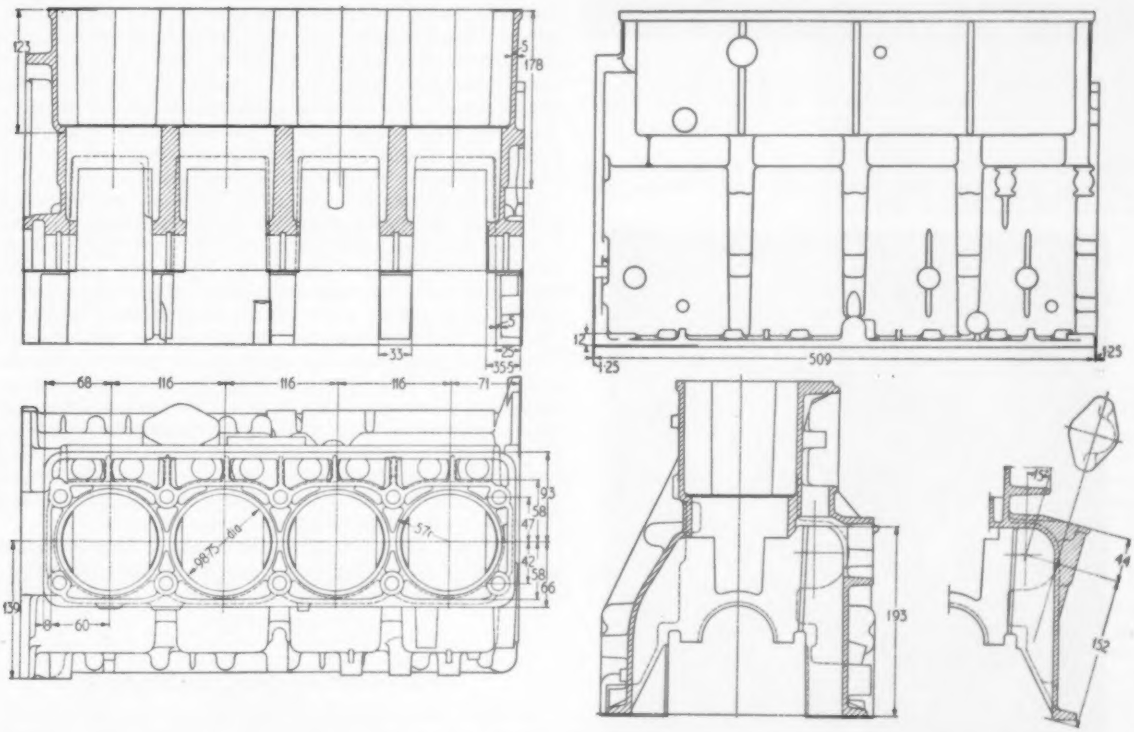
"Dosomatic" automatic ladling equipment is sited alongside the machine. In the foreground is a metal elevator for charging the melting furnace



Molten metal is delivered by the "Dosomatic" unit direct to the injection sleeve. Under thermostatic control a line of gas jets ensures that the temperature of the launder does not fall below a predetermined value

showing the casting ready for ejection from the die-half on the moving platen.

Specification and dimensions of the machine are impressive. Overall it is 54 ft 2 in long, 12 ft 2 in wide, and 17 ft 5 in high and its weight is 113 tons. The four main tie-bars that sustain the applied clamping pressure of 2,200 tons are 11 in diameter. Clear access between the tie-bars is 51 in. Exceptionally large dies can be accommodated, the overall dimensions of the platens being 78¼ in × 82¾ in. An adjustment of 19¾ in is provided for die height, permitting die height to range from a minimum of 27½ in to a maximum of 47¼ in. The full opening stroke of the moving platen is 59 in.

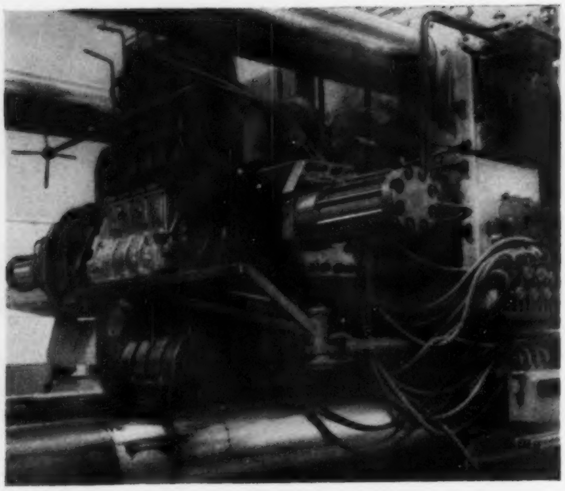


Longitudinal and transverse sections and elevation and plan of the four-cylinder block casting for the Volga 2½-litre 80 b.h.p., engine. Standard features of the die design are: taper in holes, 1 deg; taper on surfaces, 2 deg; corner radii, 3 mm; and surface machining allowance, 1·25 mm

Maximum injection capacity is 143·5 lb of aluminium and the total applied injection pressure can be selected steplessly between minimum and maximum values of 80 tons and 170 tons respectively. In cold chamber machines it is customary to feed metal to the die at a relatively low level. Accordingly, provision is made for the sleeve and the injection ram to be mounted in three different positions. The uppermost is positioned at the centre of the platen and the two others are arranged respectively 300 mm and 600 mm lower.

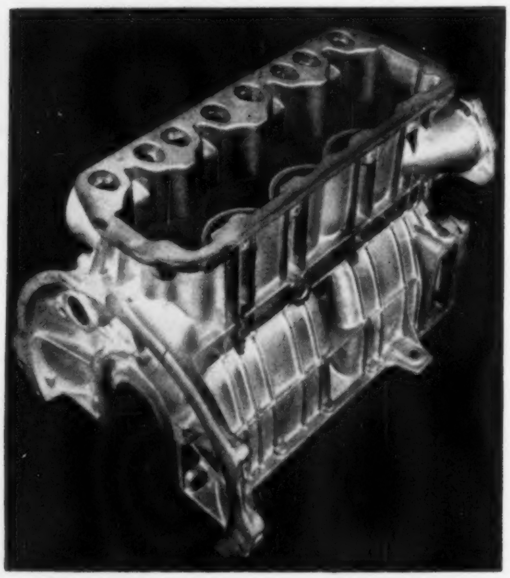
Although the machine is generally termed "all hydraulic", a positive, mechanical blocking system is included in order to exclude any possibility of inadvertent movement of the column once it has completed its closing stroke. It comprises four arcuate keying members, disposed radially around the main column and moved by hydraulic actuating cylinders in the main reaction head. At the end of the clamping stroke these keys are engaged in an annular groove in the column, precluding further movement. The arrangement is illustrated diagrammatically. This blocking action is followed by the pressurization of a very short-stroke ram (less than 1 in stroke) at the forward end of the main column. Since the main column is moved forward by jack rams, this system is very economical in water consumption.

The hydraulic power plant includes two pumps, each delivering 26·5 gal/min, with servo-controlled unloading valves. There are three 150 atm (2,200 lb/in²) accumulators, each of 220 gal capacity. An intensifier having a 2 : 1 pressure ratio and other auxiliaries and control items are mounted on the entablature on the main reaction head.



The casting is ejected from the die when an unloading platform has automatically been swung into position to receive it for transfer

A Skoda four-cylinder aluminium block produced on a 1,500-ton machine. It also is of the open-jacket type to receive inset wet-type liners



The most important item of auxiliary equipment is the "Dosomatic" automatic ladling unit. It consists of a patented, free-standing oil-fired furnace aggregate which includes both melting and holding furnaces. The "Dosomatic" device, mounted on the furnace, transfers a shot of metal from the holding furnace to the sleeve of the machine by means of air or nitrogen at a pressure of not less than 4 atm. Nitrogen is used in this instance.

Adjustment of the quantity of metal to be fed is by means of an electronic timer, and is accurate within the limits of ±2·5 per cent. The timer circuit is closed when molten metal reaches a contact at the delivery spout. Operation is initiated by push button for "one-shot" working but for continuous cycling it is controlled by an interposed pressure switch linked to the machine cycle. The time required to complete one cycle of the dosing equipment is dependent upon the weight of the shot required and extends from 15 to 40 seconds. The unit includes an automatic metal temperature control and, being in general pneumatically operated, can be easily dismantled for cleaning and maintenance. Obviously, the temperature of the launder from the furnace to the machine sleeve must not be allowed to chill or freeze the metal. Accordingly, a row of gas jets is provided immediately below the pipe. It is used on starting up from cold and, thereafter, under automatic, thermostatic control.

On the trials the machine cycle was automatically controlled from the clamping of the die to the off-loading of the casting, including the dosing of the metal into the sleeve, core movement in the die, and metal injection. On the opening of the die, the casting is retained in the half on the moving platen and off-loading is accomplished by means of a fabricated platform hingedly mounted on the outer edge of the platen. Actuated by a hydraulic cylinder through a rack and pinion mechanism, the platform is swung in front of the die and receives the casting when it is automatically ejected. It then swings out, clear of the die, with the casting ready for transfer to the knock-off station. In Russia, the machine will be run on production by only three men. One will serve as operator in the usual manner, one will remove the casting from the off-loading platform, and the other will attend the Dosomatic ladling equipment.

It would appear that as a result of their experience with two 1,500 ton Triulzi machines already operating in their country, the Russian engineers had complete confidence in the 2,200-ton machine. Before the trials were run, orders were placed for two further machines of the same capacity. These are at present under construction. Also of interest is the fact that planning and design for the dies for two V-eight cylinder blocks are already under way. The blocks will be well within the production capacity of the 2,200-ton machines. It is also reported that a 1,500-ton machine has been built for the Skoda works in Czechoslovakia. A die for a four-cylinder engine block has been completed and fifty castings (see illustration) have been dispatched to the Skoda works for testing and trials. These castings, in L M 6 and L M 24 alloys, weigh 26½ lb gross and 18¾ lb net.

In Britain, the sole agent for the complete range of Triulzi cold chamber diecasting machines is Alexander Cardew Ltd., 2, 3 and 5 Studio Place, Kinnerton Street, London, S.W.1.

Anti-Corrosion Treatment

AMONG the products of Hellermann Ltd, of Crawley, Sussex, is an anti-corrosion and anti-moisture material designated CRC 2.26. It is intended primarily for electrical and electronic equipment and has the property of penetrating pores, cracks or holes and displacing any absorbed moisture. After the moisture has been excluded, the substance forms a flexible, corrosion-inhibiting film, which is stated to act as a lubricant on moving parts. Hellermann CRC 2.26 is supplied in 16 oz aerosol dispensers, or in 1 gal and 5 gal cans and 55 gal drums for brushing on or immersion.

Gas Carburizing Plant

IN THE last paragraph of the article entitled "Gas Carburizing Plant", published in the August issue of *Automobile Engineer*, the final stress-relieving temperature of 160 to 180 deg C was inadvertently quoted as being the carbo-nitriding temperature. The actual figure for carbo-nitriding is, of course, 850 to 900 deg C. As was mentioned in the article, the process is similar to gas carburizing in that both temperature and time are related to case depth.

New Plant and Tools

Recent Interesting Developments in Production Equipment

NOW being manufactured in this country is the Coldpoint drill, which is a twist drill with a fluted shank, a hard tip, and an axial hole through which coolant fluid is taken to the work face. The device is claimed to be able to drill metals and other materials of any hardness, at high speeds and with great accuracy.

Originally patented in the United States, the Coldpoint drill is marketed in this country by Coldpoint Drills Ltd, of 49 St. James's Street, London, S.W.1, and manufactured by Horstman Ltd, of Bath, Somerset, which is a subsidiary company of Simms Motor and Electronics Corporation Ltd. Difficulties such as overheating, swarf stoppages, the need for re-sharpening and the formation of ragged holes are said to be obviated. The drill is made from steel tubing, around which shallow flutes are cut, but without a relief angle; one end of the bit is axially slotted to receive a tungsten carbide tip, which is brazed in position.

The thickness of this tip is less than the diameter of the axial hole, so that a duct of part-circular section is formed on each side of the tip and emerges level with the end of it. Naturally, after the tip has been ground and pointed, these holes stand back slightly from the point of the drill. Two main deviations from accepted practice are made: they are the employment of negative rake angle, and a slight back taper on the periphery of the hardened tip.

Since the coolant is pumped through the bore and delivered at high pressure to two sides of the point of the drill, it washes the swarf away from the cutting area and up into the flutes, to be discharged. The negative rake angle causes the chips to break into small pieces, and swarf removal is thereby facilitated. It is claimed that the mean temperature at the tip of the drill does not rise above that of the room and this feature, along with rapid removal of swarf, serves to give an accurate and smooth finish to the surface of drilled holes, so that in some cases a subsequent reaming operation is obviated.

A cutting tip of tungsten carbide is brazed into the forked end of this hollow drill, and coolant is sprayed from the exposed ends of the bore, as shown
(Coldpoint Drills Ltd.)

The coolant must be a water-soluble oil, mixed at a ratio of 10:1, and delivered at a pressure of 85 lb/in^2 through special collets or chucks. Among the examples given for the performances of Coldpoint drills on various material, are: a hole $\frac{1}{4}$ in diameter and 3 in deep in bearing bronze, 6 sec; a hole 0·668 in diameter and 3·9 in deep in nodular iron, 30·5 sec; $\frac{1}{4}$ in diameter and 1·5 in deep in 18/8 stainless steel, 50 sec; $\frac{1}{4}$ in diameter and $\frac{1}{2}$ in deep in glass, 5 sec.

No compressed air is needed with this spray gun; paint is fed at high pressure through a single hose pipe, and atomized by the spray nozzle
(Alfred Bullows & Sons Ltd.)

Gun for airless paint-spraying

In an article on page 32 of our January 1961 issue, American-built equipment for airless paint-spraying was described. It is the Graco Hydra-Spray unit, in which paint pumped at very high pressure through the nozzle of the spray gun is very finely atomized and projected at high velocity to the workpiece. The advantages claimed are economy of paint, faster application, and a more uniform finish as compared with that obtained with conventional methods of spray-painting. Recently, a lightweight spray gun, called the Golden gun, has been introduced for use with the Graco equipment, and will be distributed in Great Britain by Alfred Bullows & Sons Ltd, Long Street, Walsall, Staffs.

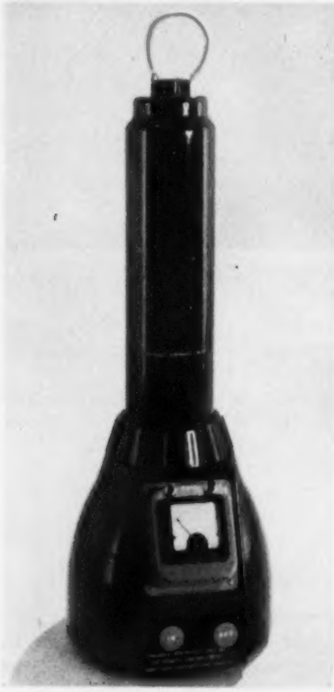
The main features of the new gun are that the single hose connection is at the base of the handle, and a swivelling coupling is incorporated in it. These features give the gun a better balance and place less restriction on the movements of the operator. A range of 17 type FF nozzles is supplied with each gun: these are sufficient for all the fine finishing applications likely to be required, ranging from high-volume and protective coating work to what are claimed to be thinner applications than have hitherto been possible. Coatings can now be applied with feathered edges, so that passes can be lapped more easily. Another feature of the gun is that the needle and seat of the valve are of tungsten carbide, so that the passage of paint does not cause erosion.

Programme-controlled multi-tool lathe

A versatile automatic multi-tool lathe of French manufacture is now being distributed in the United Kingdom through the agency of Dorman Machinery Sales Ltd, Chalfont St. Peter, Buckinghamshire. This is the Synchromat lathe, made by Salomé-Frères, of Nanterre; it is a hydraulically operated unit with plug-board setting for programme control, and it also incorporates a profile copying device. The bed is arranged vertically and has two sets of hardened and ground slideways, on each of which is mounted a sliding carriage.

Each carriage can carry one or two interchangeable transverse slide units, and the top one can, if necessary, carry a copying slide unit as well as a transverse unit. There are three types of copying units available: single pass, double pass and multi-pass, and the multi-pass unit gives four roughing passes and two profiling cuts from one template. The feed rates of the slides remain constant, regardless of variations of cutting load or the viscosity of the oil, and are steplessly adjustable between 0·157 in/min and 47 in/min. During rapid traverse motions, the speeds range from 15 to 18 ft/min.

All the rapid and fine feed motions of carriages and slide units, and the copying device, together with the operation of the chuck and tailstock, are hydraulically actuated, according to the pre-set programme on the plug-board. Two independent power sources are embodied in the Synchromat machine, one for the hydraulic controls and the other for the headstock spindle, so that the power requirements of one do not detract from that available for the other. Housed in a dust-proof, steel cabinet away from the lathe are the electrical control equipment and the plug-board, on which are selected rapid approach feeds, slow cutting feeds and the sequence of operations. The Synchromat lathe has an overall length of 10 ft 2 in, and a maximum distance between centres of 47 in; the maximum swing over the bed is 16·9 in, and that over the carriage is 11·8 in. There are two ranges of speeds available: 160-3,200 r.p.m. and 80-3,200 r.p.m.



Within the plastics body of this portable, water demineralizer is a conductivity tester, with which the purity of the water is checked from time to time. The cartridge containing activated material is replaceable, and is normally changed as soon as the purity falls below the minimum level that is normally acceptable

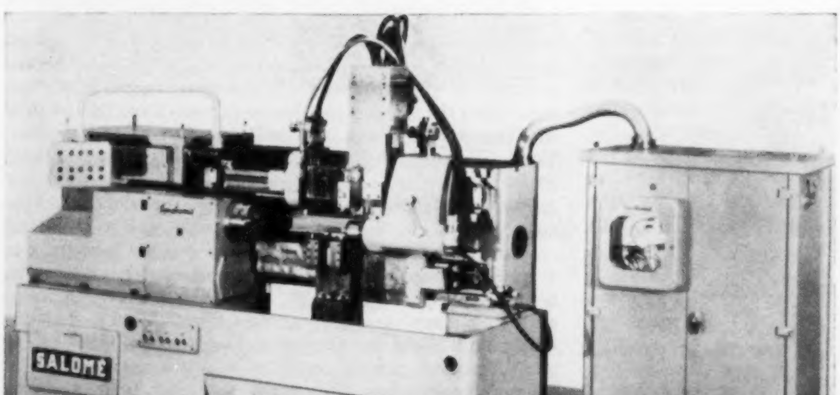
(Permutit Ltd.)

Portable demineralizer

Small quantities of purified water are occasionally needed where neither large scale plant for its production nor regular supplies from other sources can be justified. The Permutit Company Ltd, Gunnersbury Avenue, London, W.4, have recently introduced a portable plant for this type of application; it has a body of plastics material, weighs 8 lb, and is 22 in high × 8¼ in overall diameter. The equipment is called the Mk 7 Portable "Deminrolit" Unit, and it incorporates a replaceable cartridge capable of purifying up to 12 gallons of water per hour.

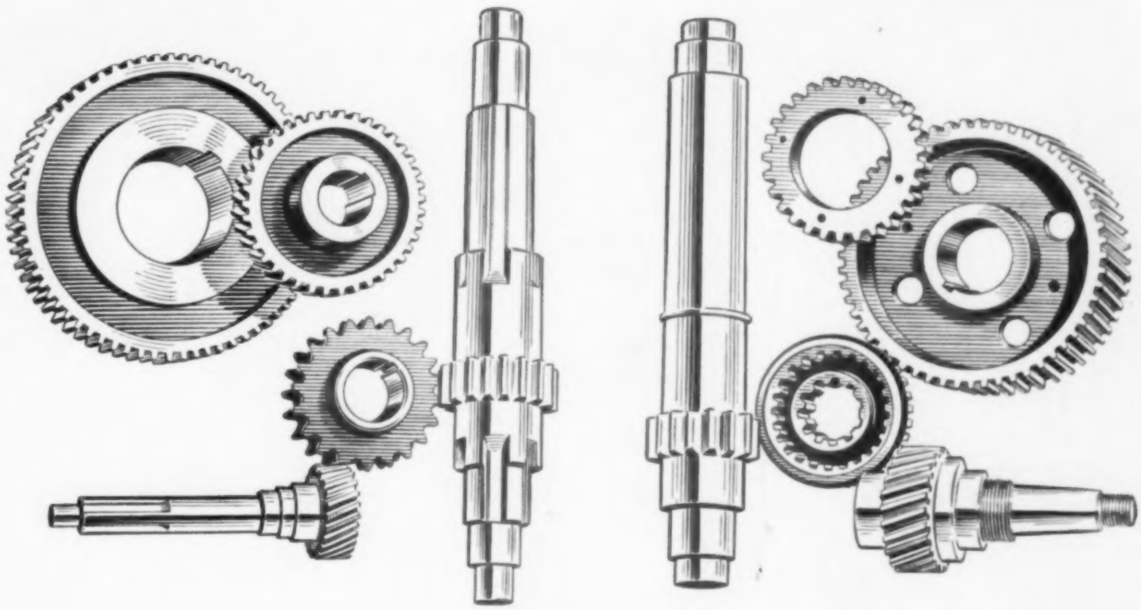
In the base of the unit there is a battery-operated conductivity tester, for monitoring the quality of the purified water. This indicates the point at which the conductivity of the water is beginning to exceed a minimum figure, and that therefore the cartridge is approaching exhaustion. Replacement of the cartridge involves only the loosening of a locking ring and disconnection of two unions.

The total throughput per cartridge varies according to the quality of water being fed in. In London, for example, the figure is 16 gallons, but in other locations where water is much softer, it can be more than 200 gallons. Any water that has been purified by the Deminrolit Mk 7 complies with the B.P. specification for purified water, and is suitable for, among other things, topping-up lead-acid accumulators.



The bed of this multi-tool automatic lathe is vertical, for ease of access and maintenance. On each of the two carriages there are two slide units, one of which can be a copying unit. A plug-board, for programme control, is housed in the control cabinet seen on the right

(Dorman Machinery Sales Ltd.)



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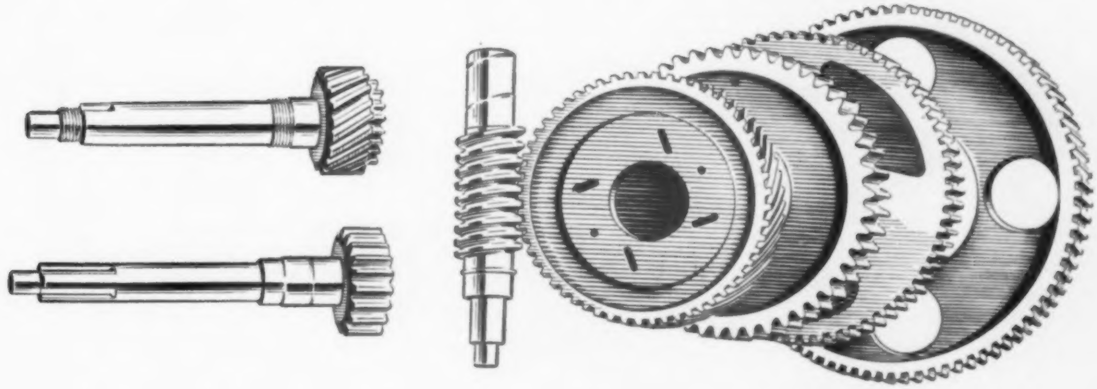

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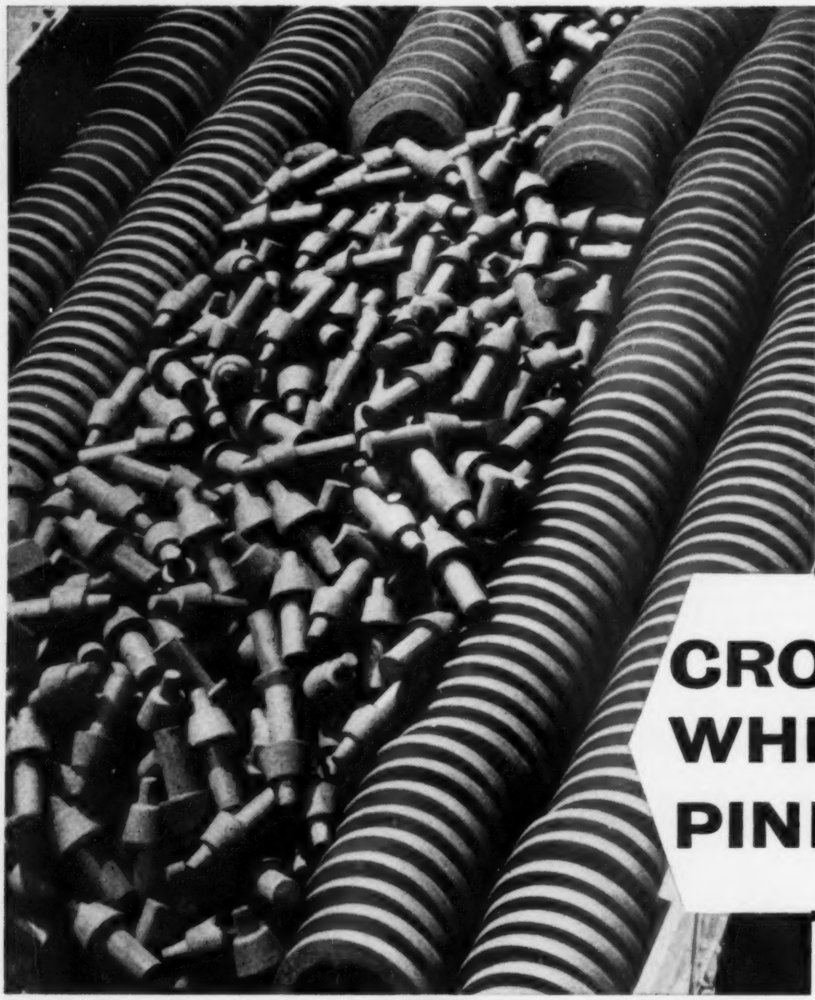

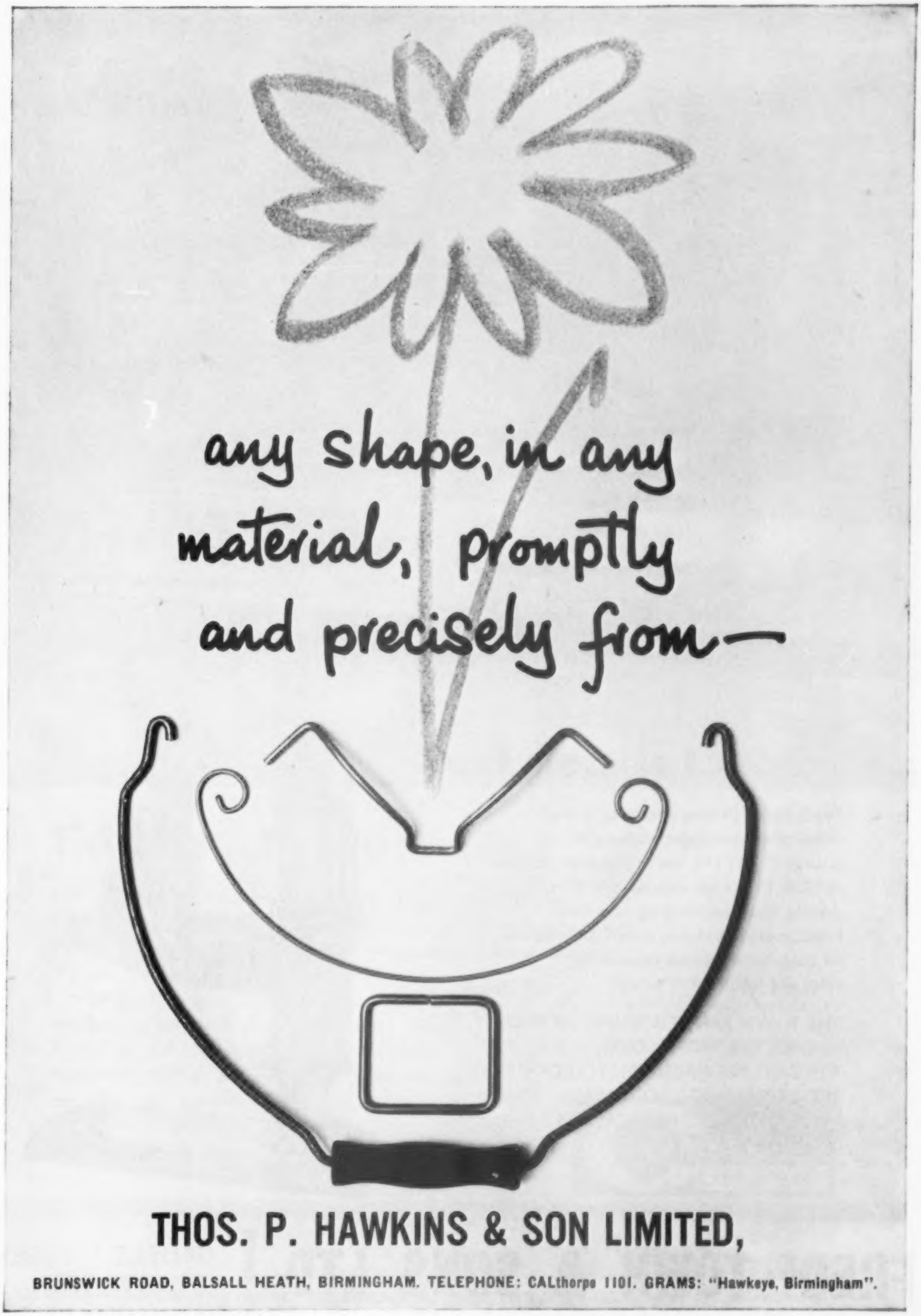

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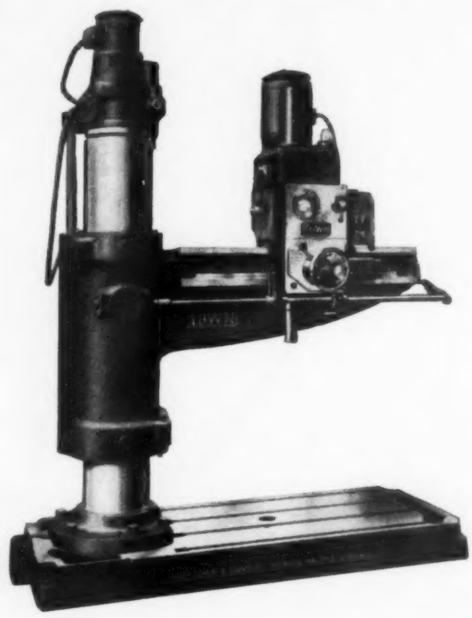

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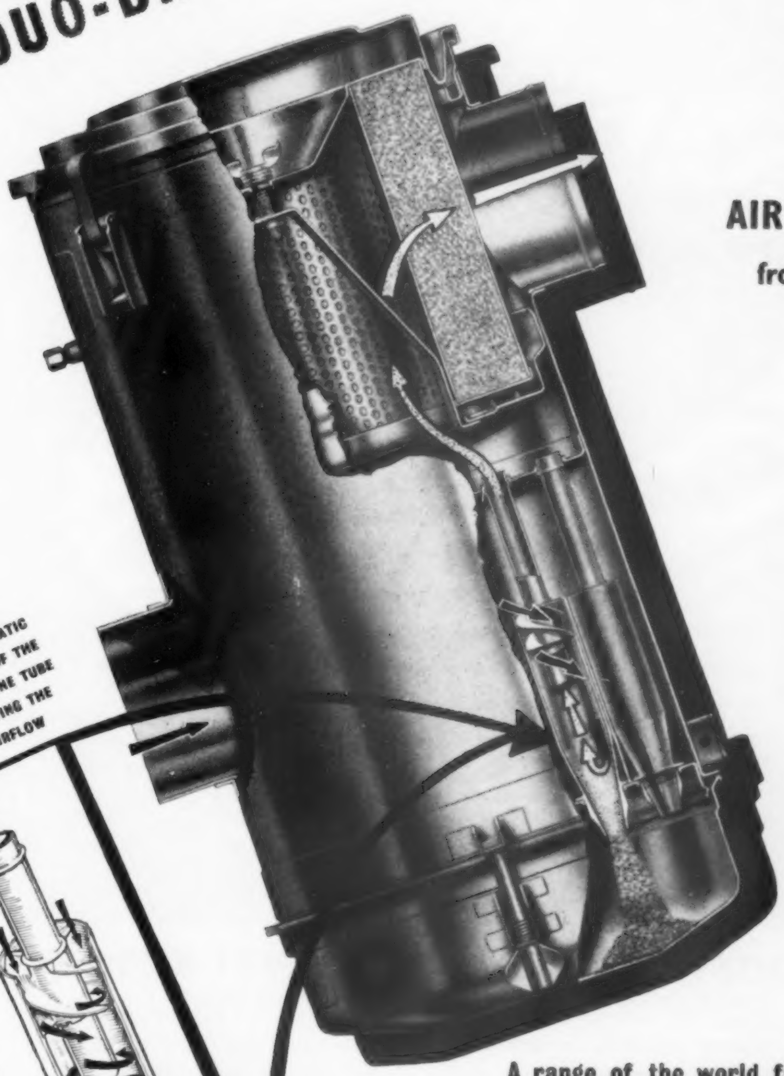

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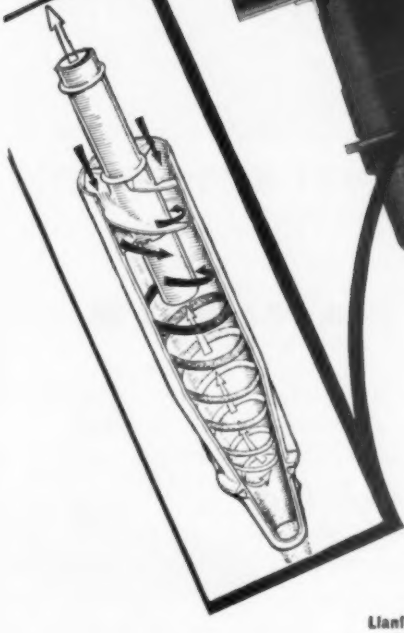

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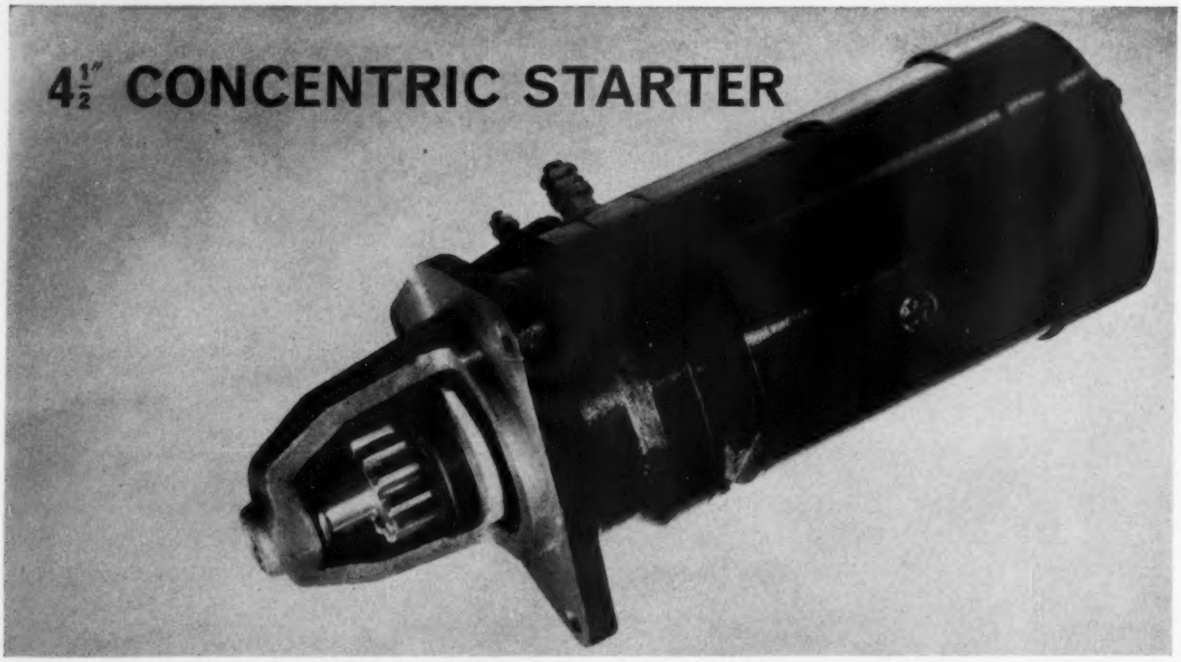

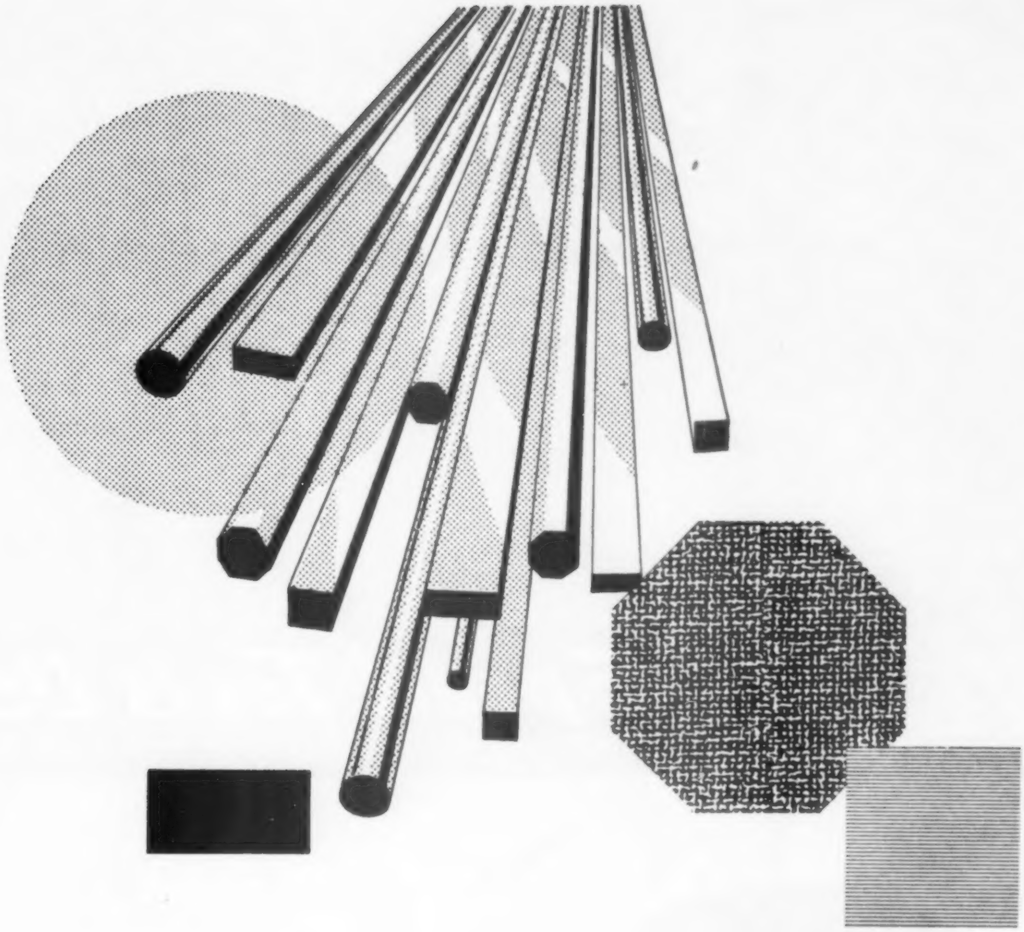

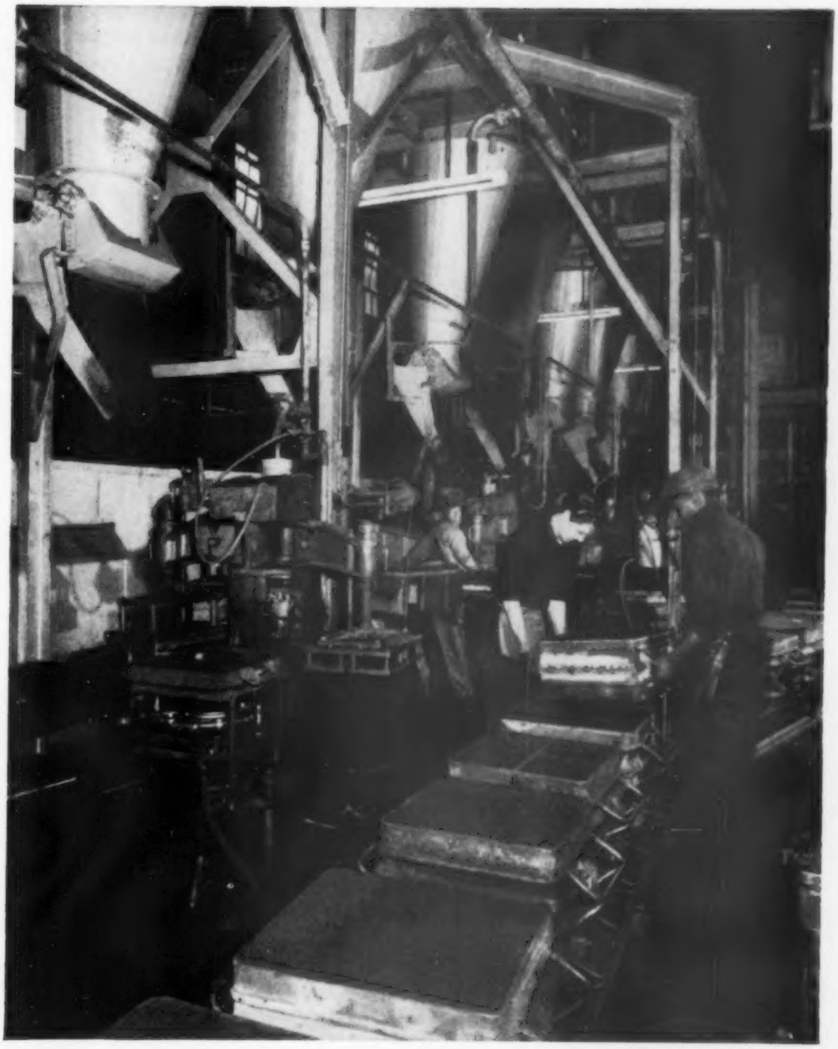

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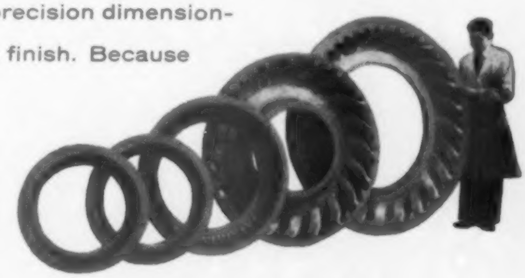

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AP 130

GLACIER *DU for AEC

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* Glacier DU dry bearings are composed of thin steel strip with a porous bronze coating impregnated with a mixture of a fluoro-carbon plastic (P.T.F.E.) and lead.

AEC Bridgemaster King-pin assembly fitted with DU bushes.

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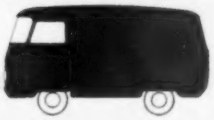
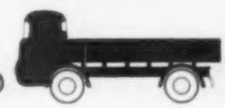
D.U. for COMMER	D.U. for GUY	D.U. for Albion
		
D.U. Thrust washers and bushes fitted as standard equipment on the King-pins of the [illegible] ton range of vehicles.	*D.U. dry bearings and bushes fitted as standard equipment on brake, clutch and steering mechanisms, King-pins and on throttle linkage on the Wulfrunian bus chassis.*	*DU Thrust washers fitted as standard equipment on steering pivot pins of the Series II Chieftain.*

For details of the range and properties of Glacier dry bearings, write for a free copy of the Designer's Handbook No. 2 to :—

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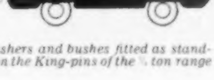
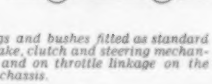


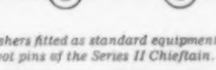
D.U. Thrust washers and bushes fitted as standard equipment on the King-pins of the [illegible] ton range of vehicles.

D.U. for GUY



D.U. dry bearings and bushes fitted as standard equipment on brake, clutch and steering mechanisms, King-pins and on throttle linkage on the Wulfrunian bus chassis.

D.U. for Albion



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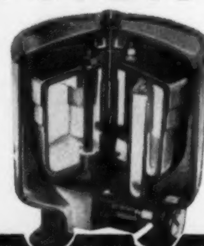

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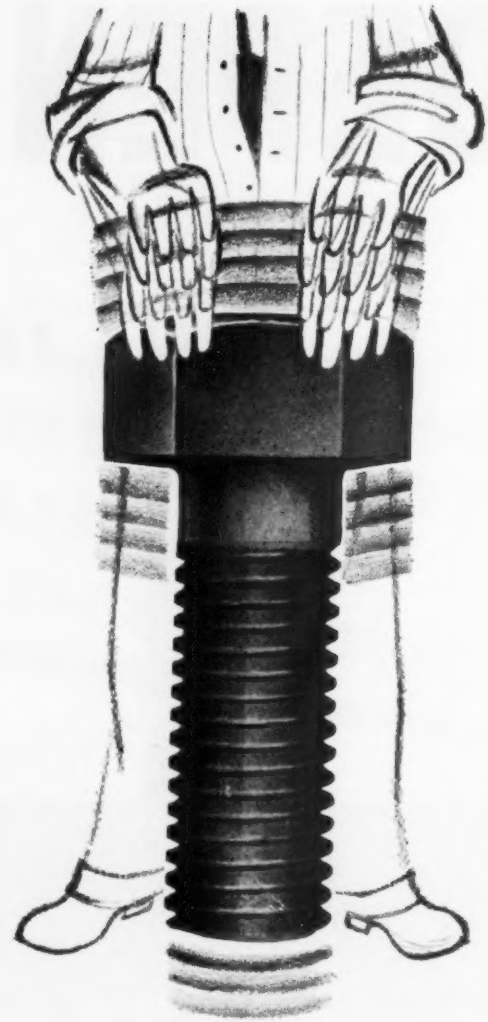

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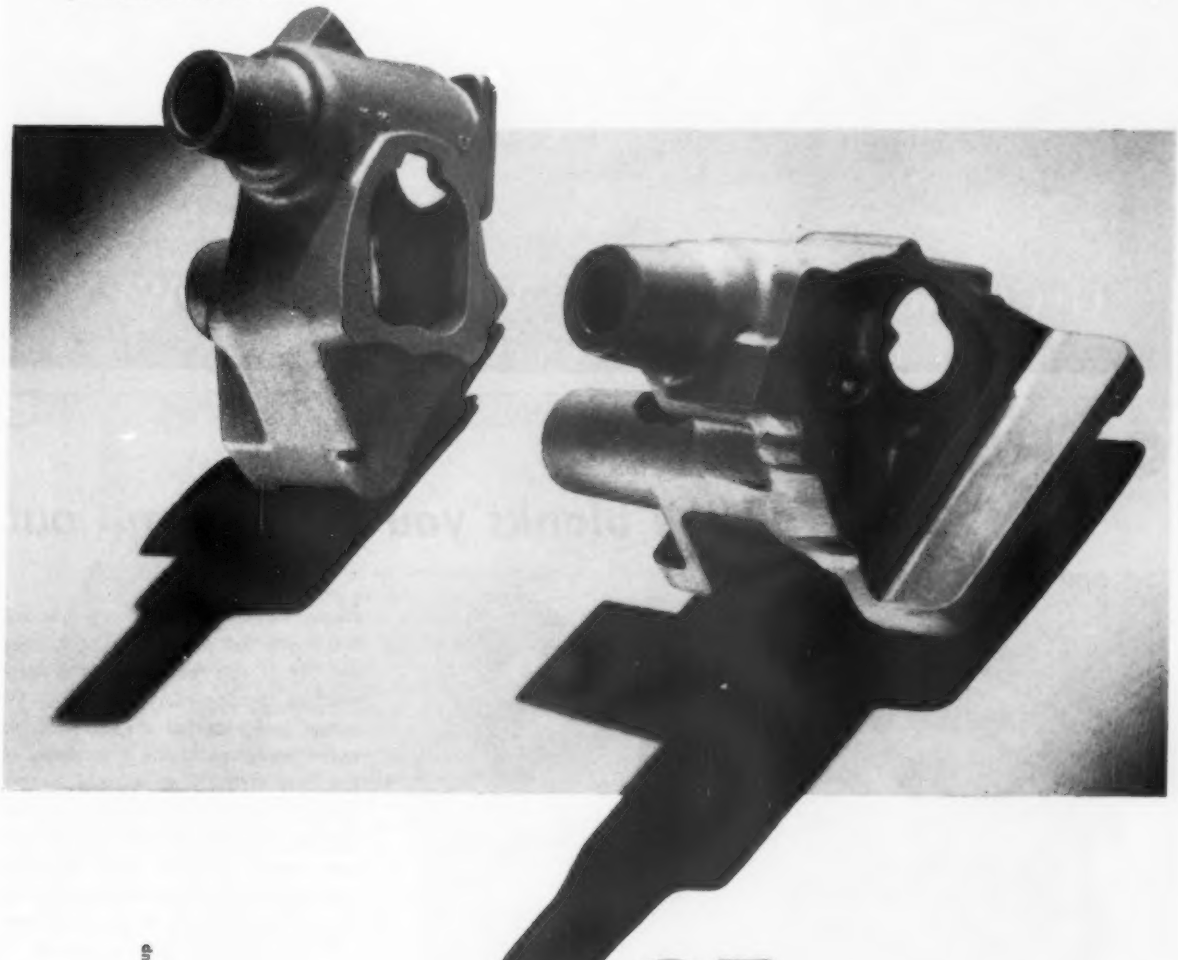

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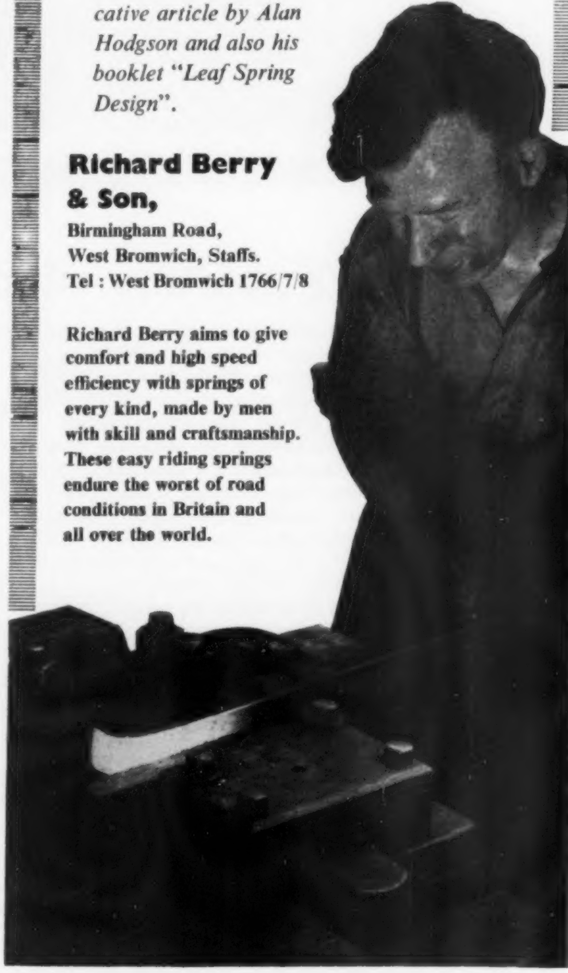

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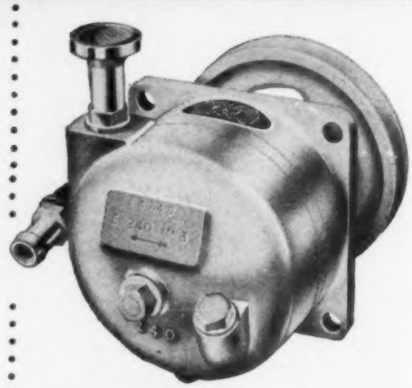

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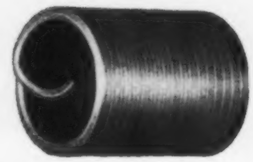

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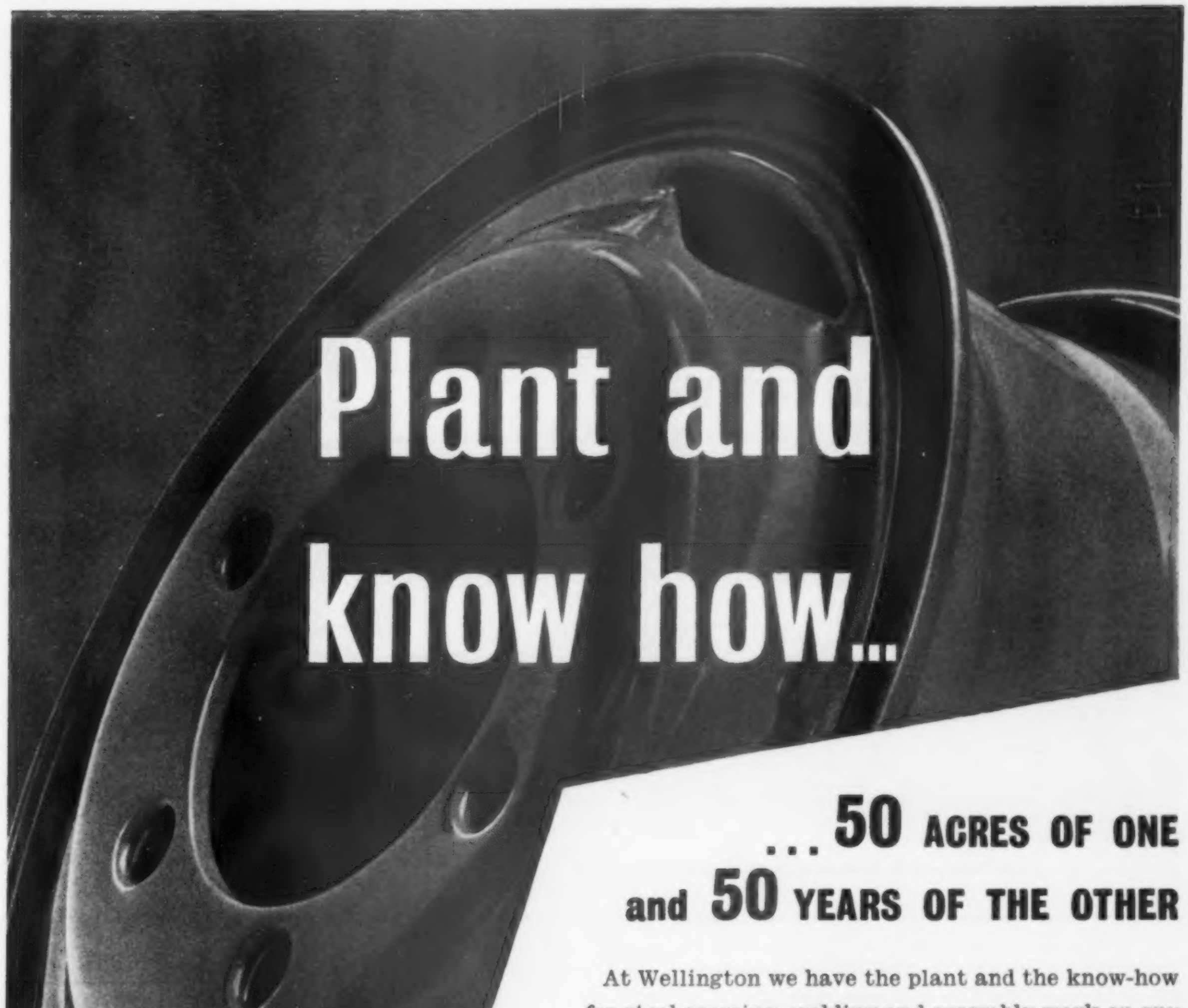

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